



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

SYSTEMS FRAGILITY: THE SOCIOLOGY OF CHAOS

by

Lori R. Hodges

March 2015

Thesis Advisor:
Second Reader:

Robert Josefek
Wayne Porter

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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE March 2015	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE SYSTEMS FRAGILITY: THE SOCIOLOGY OF CHAOS			5. FUNDING NUMBERS	
6. AUTHOR(S) Lori R. Hodges				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB protocol number ____N/A____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) This thesis seeks to examine the concept of community fragility in emergency management from a systems perspective. Two questions are studied. First, can community fragility be qualitatively measured? Second, does this concept hold value for the emergency management field? Using literature that addresses fragility in four areas of complex systems—ecosystems, social systems, socio-technical systems, and complex adaptive systems—we create a theoretical framework focused on the emergency management field. This theoretical framework is then assessed through a multi-case analysis, examining three diverse large-scale events that have occurred in the United States in the past decade. Assessing each fragility factor from the theoretical framework for each case study reveals that the framework is sound. These findings allow for the development of a causal prediction model illustrating how community fragility factors can be used in the emergency management field to not only improve overall outcomes after disaster, but to also build less fragile systems and communities in preparation for future disasters.				
14. SUBJECT TERMS complexity, systems theory, systems, fragility, emergency management, socio-technical, social capital, resilience, vulnerability			15. NUMBER OF PAGES 171	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

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Lori R. Hodges

Director of Emergency Management, Larimer County Government, Fort Collins, CO

B.A., Metropolitan State University, 2005

M.A., University of Colorado at Denver, 2006

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)**

from the

**NAVAL POSTGRADUATE SCHOOL
March 2015**

Author: Lori R. Hodges

Approved by: Robert Josefek
Thesis Advisor

Wayne Porter
Second Reader

Mohammed Hafez
Chair, Department of National Security

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ABSTRACT

This thesis seeks to examine the concept of community fragility in emergency management from a systems perspective. Two questions are studied. First, can community fragility be qualitatively measured? Second, does this concept hold value for the emergency management field? Using literature that addresses fragility in four areas of complex systems—ecosystems, social systems, socio-technical systems, and complex adaptive systems—we create a theoretical framework focused on the emergency management field. This theoretical framework is then assessed through a multi-case analysis, examining three diverse large-scale events that have occurred in the United States in the past decade. Assessing each fragility factor from the theoretical framework for each case study reveals that the framework is sound. These findings allow for the development of a causal prediction model illustrating how community fragility factors can be used in the emergency management field to not only improve overall outcomes after disaster, but to also build less fragile systems and communities in preparation for future disasters.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARC	American Red Cross
CAIB	Columbia Accident Investigation Board
Cal EMA	California Emergency Management Authority
CART	Citizens Advisory Recovery Team
CERT	Community Emergency Response Team
CHDS	Center for Homeland Defense and Security
CIA	Central Intelligence Agency
DHS	Department of Homeland Security
DOC	Department Operations Center
EF	Enhanced Fujita Scale
EMAC	Emergency Management Assistance Compact
EMMA	Emergency Management Mutual Aid
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FCC	Fire Communications Center
FEMA	Federal Emergency Management Agency
FBI	Federal Bureau of Investigation
FIRESCOPE	Firefighting Resources of Southern California Organized for Potential Emergencies
FMAG	Fire Management Assistance Grant
ICS	Incident Command System
JIC	Joint Information Center
LAC	Local Area Assistance
MACC	Multi-Agency Coordination Center
MCEER	Multidisciplinary Center for Earthquake Engineering Research
NPS	Naval Postgraduate School
NRP	National Response Plan (now the National Response Framework)
OAEOC	Operational Area Emergency Operations Center
OEM	Office of Emergency Management
OES	Office of Emergency Services

OSCC	Southern California Geographic Area Coordination Center
UNISDR	United Nations International Strategy for Disaster Reduction
VOAD	Voluntary Organizations Active in Disaster
WUI	Wildland Urban Interface

EXECUTIVE SUMMARY

Over the last decade, the United States alone has averaged at least one large-scale crisis or extreme event per year. In this environment of complex disasters, we see differences in how communities respond and recover. In some of these disasters, the community bands together and recovers faster and to be stronger than before. In other cases, the disaster cripples the community, leaving it for years to come in ruins, socially, politically, and economically.

This thesis takes a new approach to the study of community response and recovery. It examines the concept of community fragility in emergency management from a systems perspective based on research in fields outside emergency management. The assertion is that 1) there is a gap in the current emergency management literature and policies with regard to community fragility and what causes systems to fail, and 2) there should be a way to qualitatively measure fragility as an emergency management concept. Therefore, two questions are studied. The first is whether community fragility can be qualitatively measured, and the second is whether this concept has value in the emergency management field.

This research uses a multi-method approach to answer these questions. Using literature that addresses fragility in four areas of complex systems—ecosystems, social systems, socio-technical systems, and complex adaptive systems—we create a theoretical framework focused on the emergency management field.

Using multi-case analysis, this framework is refined to include factors affecting community fragility within the emergency management field. The findings of the case studies allowed for the development of a community fragility causal prediction model illustrating how community fragility factors can be used in the emergency management field to not only improve overall outcomes after disaster but to also build stronger systems and communities in preparation for future disasters.

Three themes were developed from an examination of the research: connectedness, stability, and sustainability. Recent trends have shown an increase in

focus upon resilient communities, but as shown in this research, resiliency is merely one factor of the whole. Along with resiliency, there are factors that affect the sustainability of a community. Additionally, the connections between community members, public officials, and emergency management practitioners play a role as well as the overall stability of the community before the disaster strikes. This could explain why plans and procedures so often fail despite the best efforts of everyone involved—they were looking through a lens that was too small.

Each one of the case studies chosen for this research illustrated key concepts that are critical to emergency management when looking into the future. The first is the understanding that our disaster landscape is not the same as it was when the discipline of crisis management emerged in the 1950s and 1960s. At that time, crisis managers looked at a specific problem or a potential disturbance within a system. The aim was the same—to stop a cascading event from occurring. Managers assumed, however, that the triggering event would be stable and recognizable. With the increase in complexity in the twenty-first century, along with our highly interdependent global network, we have entered into a new era where we face greater instability and less recognizable problems. This research illustrates this new environment by outlining various factors of fragility from a systems perspective. The research does not end at risk and vulnerability assessments. Instead, it recognizes the importance of these factors along with the importance of social structure of a community, the leaders who shape policy, the interdependencies of our critical infrastructure, the structure of emergency management systems, and the people who put it all together.

The concept of fragility alone is significant to the field of homeland security and emergency management. While studied in several other disciplines and fields, our hope is that this important idea will gain momentum in the area of disaster management. Doing so will cause a change in focus. Instead of looking merely at how to reduce a threat, the inclusion of fragility allows emergency managers to turn around and see the connections between multiple parts and pieces of the whole. Managers may plan everything out well

and execute as expected, only to see the event unravel and fail. The focus on fragility brings to light areas previously hidden that explain these failures and provide a roadmap to success in the future.

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ACKNOWLEDGMENTS

Many people assisted me throughout the CHDS program and in the development of this thesis. First, I would like to thank both Yonette Hintzen-Schmidt with the Colorado Office of Emergency Preparedness and Response and Linda Hoffmann with Larimer County for supporting my educational goals and allowing me to attend this program. I realize the amount of time taken away from work to complete program requirements was extensive, and both managers provided the necessary support to complete my goals.

Undoubtedly, this thesis would not have been possible without the support I received from my thesis advisor, Robert Josefek, and my second reader, Wayne Porter. Both were engaged with the topic and research from the beginning of this journey and provided just the right amount of guidance and support necessary to create this thesis. Robert was also able to provide comments and suggestions throughout each phase of thesis development while still allowing me to maintain my own voice, which was truly remarkable.

I would also like to thank my mother, Barbara Pate, for her constant advice and guidance—in life and during this program. She helped translate complex research concepts and practices into meaningful action and was the one person I always knew would be on the other end of the phone when frustration set in or when I thought my head might explode.

Finally, I would like to thank my cohort, who continued to challenge my assumptions and led me to think more broadly about homeland security issues.

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I. INTRODUCTION

“The fragile wants tranquility, the antifragile grows from disorder.”

–Nassim Nicholas Taleb

Late in the evening on May 4, 2007, a series of 22 tornadoes formed in Kansas. One of these storms created an EF5¹ tornado that killed 11 people and destroyed the declining farm town of Greensburg, Kansas.² After the initial shock of the event passed, the community members saw the destruction as an opportunity to re-create their community and to strengthen it against future storms in the process. Using renewable energy options for rebuilding efforts within three years, Greensburg has been transformed into a “green” community. It is now a model community not only for renewable energy but also for community recovery after disaster.³

Sadly, many other communities do not share the same fate. In 1993, nearby Chesterfield, Missouri, was inundated by flood waters in a multi-state flood event affecting the entire 32.5 mile town and a population of 50,000 people. Unlike Greensburg, however, Chesterfield did not recover fully. One study reported that Chesterfield lost 200 businesses in the flood and over two-thirds of those businesses never recovered.⁴

What makes one community falter after disaster while another thrives and grows stronger in the process? Is there a formula for success that communities can follow to ensure a recovery that not only gets them back on track but increases the odds of a better

¹ Enhanced Fujita Scale. EF5 is the highest level rating for a tornado.

² Leslie Lemon, and Mike Umscheid, *The Greensburg, Kansas Tornadoic Storm: A Storm of Extremes* (Norman, OK: Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, 2008), <https://ams.confex.com/ams/pdfpapers/141811.pdf>, 2.4.

³ Shanti Pless, Daniel Wallach, and Lynn Billman, “From Tragedy to Triumph: Rebuilding Greensburg, Kansas, to Be a 100% Renewable Energy City” (presented at the National Renewable Energy Laboratory, ACEEE Summer Study Conference, Pacific Grove, CA, 2010), NREL/CP-550-48300, <http://energy.gov/sites/prod/files/2013/11/f5/48300.pdf>, 4.

⁴ Clara Beitin, *The Great Flood of 1993: The Important Role of State and Local Governments*, Pace University, accessed January 20, 2015, <http://landuse.law.pace.edu/landuse/documents/StudentArticle/Reg7/MidwestFlood.doc>

outcome in the future? More importantly, is there a way to determine the point at which a community's ability to withstand shocks and disturbances from disasters ends and system failures begin to occur?

A. PROBLEM STATEMENT—BACKGROUND

Over the last decade, the United States alone has averaged at least one mega-crisis per year.⁵ A mega-crisis is a distinguishing factor between the disaster that remains within the community's capacity to respond and recover, and that which exceeds that capacity.⁶ In a book called *Mega-Crises: Understanding the Prospects, Nature, Characteristics and the Effects of Cataclysmic Events*, it states, "Mega-crises are not just 'more of the same;' they present a new class of adversity with many 'unknowns.' They defy boundaries, limits, neat demarcations, patterned connections and linear consequences."⁷ These types of events challenge all of our basic assumptions about response and recovery from large-scale events. They also challenge our assumptions about the methods used by political leaders, emergency responders, and community members. With these challenges come solutions that often diverge or conflict as complex problems do not have simple answers.⁸

This increase in mega-disasters or mega-crises is partially responsible for a new degree of complexity we are seeing in emergency management. We have more people living in areas susceptible to wildfires, flooding, tornadoes, and coastal disasters than ever before in our history.⁹ And though the causes of climate change are yet to be fully explained, our nation has experienced dramatic weather and climate changes over the last

⁵ Federal Emergency Management Agency, "Disaster Declarations," 2014, <http://www.fema.gov/disasters>

⁶ Marc Landy, *Climate Adaptation and Federal Megadisaster Policy: Lessons from Katrina*, Resources for the Future Issue Brief 10-02 February 2010, <http://www.rff.org/RFF/Documents/RFF-IB-10-02.pdf>, 2.

⁷ Ira Helsloot, ed., *Mega-Crises: Understanding the Prospects, Nature, Characteristics, and the Effects of Cataclysmic Events* (Springfield, IL: Charles C. Thomas Publishing, 2012), 5.

⁸ Ibid.

⁹ Ibid.

decade, compounding the dangers people face from large-scale disasters. Jeffrey Kluger, *TIME Magazine*, reports,

Wildfires in such regions as Indonesia, the western U.S. and even inland Alaska have been increasing as timberlands and forest floors grow more parched. The blazes create a feedback loop of their own, pouring more carbon into the atmosphere and reducing the number of trees, which inhale CO₂ and release oxygen.¹⁰

With climate change, the destruction from extreme events such as hurricanes, floods, and wildfires is more pronounced, leading to increased overall costs of recovery. According to Erwann Michel-Kerjan and Frederic Morlaye with the International Association for the Study of Insurance, “There have been as many as four times more Category 4 and 5 hurricanes during the period 1996–2005 than during the period 1900–1925.”¹¹ Additionally, two studies in 2005 found that the number of Category 4 and 5 hurricanes worldwide have doubled in the last 35 years, and the wind speed of all hurricanes has increased almost 50 percent.¹² In 2005 and 2006, the insured losses from Hurricane Katrina, Rita, and Wilma were estimated at \$85 billion, another historical record.¹³ Disasters in 2011 set a new record of \$366 billion for economic losses, with 29,782 deaths associated with over 302 major disasters.¹⁴

Routine crises and emergency situations can be managed with normal structures in place, but once the event passes into the realm of the mega-crisis or extreme event, many of those tried and tested structures cease to support the community. Gustav Koehler, Guenther Kress, and Randi Miller, at California State University, wrote,

Managing complex, chaotic, and high level crises requires different sets of knowledge, skills, and preparation that involve decision making, central

¹⁰ Jeffrey Kluger, “Earth at the Tipping Point: Global Warming Heats Up,” *TIME*, March 26, 2006, accessed December 27, 2014, <http://content.time.com/time/magazine/article/0,9171,1176980,00.html>, 37.

¹¹ Erwann Michel-Kerjan, and Frederic Morlaye, “Extreme Events, Global Warming, and Insurance-Linked Securities: How to Trigger the ‘Tipping Point,’” *The Geneva Papers on Risk and Insurance: Issues and Practice* 33, no. 1 (2008): 76.

¹² Kluger, “Earth at the Tipping Point,” 34.

¹³ Michel-Kerjan, and Morlaye, “Extreme Events, Global Warming,” 154.

¹⁴ Roxana Ciurean, Dagmar Schroter, and Thomas Glade, “Conceptual Frameworks of Vulnerability Assessments for Natural Disasters Reduction,” in *Approaches to Disaster Management: Examining the Implications of Hazards, Emergencies and Disasters*, ed. John Tiefenbacher (Rijeka: Intech, 2013), 3.

and yet flexible organizational structures, and a leadership capacity to stay on top of the crisis that is unfolding with dynamic changes.¹⁵

They go on to state that during times of instability, it is essential to recognize that stability can only be regained by introducing a bit of instability into these environments with communities and networks that are dynamic and fluid.¹⁶ By looking at these events differently, it may be possible to better understand and anticipate how and when systems fail as these events progress from the routine into the complex.

B. RESEARCH QUESTIONS

1. Primary Question
From an emergency management perspective, how can the fragility of a community be measured and what are its implications?
2. Secondary Question
If community fragility can be qualitatively measured, is that measurement a useful tool in emergency management? For example, would a larger network of local emergency management partners increase or decrease the fragility of a community with regard to response and recovery from large-scale emergencies and disasters, and does the governmental structure and trust in elected or key officials make a community more or less fragile to future disasters?

C. THEORETICAL FRAMEWORK

In this environment of mega-crises and complex disasters, we see differences in how communities respond and recover. In some of these disasters, the community bands together and recovers faster and becomes stronger than before, such as the community of Greensburg, Kansas did.¹⁷ In other cases, the disaster cripples the community, leaving it in ruins for years to come, socially, politically, and economically.¹⁸ The idea of

¹⁵ Gus Koehler, Guenther Kress, and Randi Miller, *What Disaster Response Management Can Learn from Chaos Theory* (Darby, PA: Diane Publishing, 1995), http://www.library.ca.gov/crb/96/05/over_2.html, 13.

¹⁶ Ibid., 14.

¹⁷ Patrick Quinn, "After Devastating Tornado, Town Is Reborn 'Green,'" *USA Today, Green Living Magazine*, April 25, 2013, <http://www.usatoday.com/story/news/greenhouse/2013/04/13/greensburg-kansas/2078901/>

¹⁸ Kim Ann Zimmermann, "Hurricane Katrina: Facts, Damage and Aftermath," *Live Science*, August 20, 2012, <http://www.livescience.com/22522-hurricane-katrina-facts.html>

community fragility is explored as an emergency management concept to identify those community structures and emergency systems that strengthen a community overall.

There is very little research on fragility as an emergency management concept. Most studies involve fragile ecological systems or fragile nation states, each of which have similarities to emergency management but are not specific to this field.¹⁹ Additionally, words such as “resilience” and “vulnerability” are common terms to describe hazards and the ability to recover from an event but are inadequate to describe a system failure, or “tipping point,” where a community may no longer be able to fully recover. Therefore, this research seeks to examine how we measure these failures, the points of fracture, and determine whether this measurement can assist communities before disaster occurs.

This research will not include an analysis of social networking (Facebook, Twitter, etc.), loose social groups, or unaffiliated volunteers. Instead, the focus will remain on primary emergency management systems, such as political systems, emergency systems, and the strength of community organization. Network analysis will be used to determine the strengths and weaknesses of these connections or links between members of a community and to analyze the impact of those partnerships on the overall ability of the community to not only recover but to become less fragile for future events. Additionally, key emergency management standards and practices will be analyzed to determine if points of fragility in these systems can be measured, allowing for change to occur prior to a disaster affecting a community. Therefore, while the topic centers on fragility at a community level, this paper will use systems and networks theory to synthesize data and analyze the results.

The assertion of this thesis is that 1) there is a gap in the current emergency management literature and policies with regard to community fragility and what causes systems to fail, and 2) there should be a way to qualitatively measure fragility as an emergency management concept. This topic has the potential to show a weakness in our

¹⁹ Paul Schuler, “International Policy toward Fragile States and the Fate of the Nation State: An Interview with IR/PS Professor Miles Kahler,” *Journal of International Policy Solutions* (Spring 2007): 7, <http://irps.ucsd.edu/assets/012/6362.pdf>

concept of emergency management at the community level, specifically with regard to those areas in which we attempt to create solutions but instead increase fragility of the system in the future. Dirk Helbing, a physicist and professor at the Swiss Federal Institute of Technology in Zurich, explains this weakness in his paper on emerging systemic risks. He states,

It is shown that linear, experience-based, or intuitive approaches often fail to provide a suitable picture of the functioning of social and economic systems. This leads to the illusion of control and a dangerous logic of failure, which can lead to paradoxical system behaviours, unwanted side effects, and sudden regime shifts.²⁰

Therefore, while concentrating on quick and full recovery from disasters, it is equally important to determine ways in which we can strengthen the system for the next disaster.

D. SIGNIFICANCE OF RESEARCH

This research will help determine if the fragility of a community can be qualitatively measured and whether that measurement can lead to stronger emergency management and community networks in the future. For over 30 years, the emergency management community has been working to control and manage large-scale incident response. Over the same amount of time, social scientists have been studying complex systems and networks requiring flexibility and adaptability in order to survive.²¹ These two schools of thought converge with the study of fragility in emergency management. No longer will the focus remain on being resilient, or “bouncing back” to normal after a disaster, but instead on building systems and structures that allow a community to gain strength and decrease their fragility before the next disaster. Nassim Nicholas Taleb states, “Almost all people answer that the opposite of ‘fragile’ is ‘robust,’ ‘resilient,’ ‘solid,’ or something of the sort. But the resilient, robust (and company) are items that neither break nor improve.”²² The concept of fragility makes communities not only look

²⁰ Dirk Helbing, *Systemic Risks in Society and Economics* (Zurich, Switzerland: International Risk Governance Council, 2010), 1.

²¹ John Harrauld, “Agility and Discipline: Critical Success Factors for Disaster Response,” *Annals of the American Academy of Political and Social Science* 604, no. 1 (2013): 256.

²² Nassim Nicholas Taleb, *Antifragile: Things That Gain from Disorder* (New York: Random House Trade Paperbacks, 2014), 32.

at resiliency and sustainability, but it also leads to a forward-looking philosophy of decreasing the things that made them vulnerable in the first place.

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II. LITERATURE REVIEW AND CONCEPTUAL DEVELOPMENT

“A changing, uncertain world in transformation demands action to build the resilience of the social-ecological systems which embrace all of humanity.”

–Carl Folke

A. INTRODUCTION

Many theories exist regarding the proper structure and function of emergency management and community systems in disasters. Although the literature covers a wide variety of such theories, this review primarily focuses on their application to the theory of community fragility. Because this term is not a common or well-established term in emergency management, Part I of the literature review begins with a section on key research terms definitions, including terms such as resiliency, vulnerability, and risk, which have all been used to some degree to determine degrees of fragility.

Due to the complex nature of emergency management, research into diverse complex systems was utilized to determine what characteristics may constitute fragility. Several complex systems, including ecosystems, social systems, socio-technical systems, and complex adaptive systems, were studied as the baseline for this research. To make the connection between the literature and emergency management and begin the conceptual development, a conceptual analysis was added to each section, providing research and data on the applicability of findings in each complex system to the field of emergency management. Part II of the literature review presents prior studies related to fragility by first presenting existing literature and then applying that literature to emergency management. This structure is repeated throughout the literature review in each complex system studied.

B. PART I: KEY RESEARCH TERMS AND DEFINITIONS

The terms risk and vulnerability are often used in emergency management to describe the state of a community before a disaster, but they are also often misused and

confused. Many emergency management analysts agree that vulnerability is based upon a hazard, specifically the frequency and severity if that hazard was to occur.²³ Therefore, a vulnerability analysis is used to determine how vulnerable a community is to a specific hazard occurring and whether that hazard will cause minimal or maximum harm (see Figure 1).

Vulnerability: Susceptibility to damage or harm

Figure 1. Thesis Definition of Vulnerability

In contrast, the dictionary definition of risk is, “exposure to the chance of injury or loss.”²⁴ According to the United Nations International Strategy for Disaster Reduction (UNISDR) report, there are two essential elements in the formulation of risk: 1) a potential hazard, and 2) the degree of susceptibility, or the vulnerability to the hazard (see Figure 2).²⁵

Risk: The degree of susceptibility (vulnerability) and exposure to a hazard and the capacity to respond

Figure 2. Thesis Definition of Risk

Dirk Helbing describes systemic risks as those that do not just have independent failures but interdependent, or “cascading,” failures in a system with multiple interconnections. He states, “Systemic risks result from connections between risks (networked risks).”²⁶ In such cases, a localized initial failure could have disastrous

²³ Joern Birkmann, “Risk and Vulnerability Indicators at Different Scales: Applicability, Usefulness and Policy Implications,” *Environmental Hazards* 7 (2007): 21.

²⁴ *Dictionary.com*, s.v. “Risk,” accessed December 27, 2014, <http://dictionary.reference.com/browse/risk?s=t>

²⁵ Ciurean, Schroter, and Glade, “Conceptual Frameworks of Vulnerability,” 5.

²⁶ Dirk Helbing, “Globally Networked Risks and How to Respond,” *Nature* 497, no. 7447 (May 2013): 51, doi:10.1038/nature12047.

effects and cause infinite damage (see Figure 3). For example, a tree limb may strike a power line at a vulnerable part of the larger electric system. This could cause a overloading in the system and transformer failures affecting a much larger area. If not caught and corrected soon enough, the simple tree limb could cause a large-scale power blackout affecting millions of people.

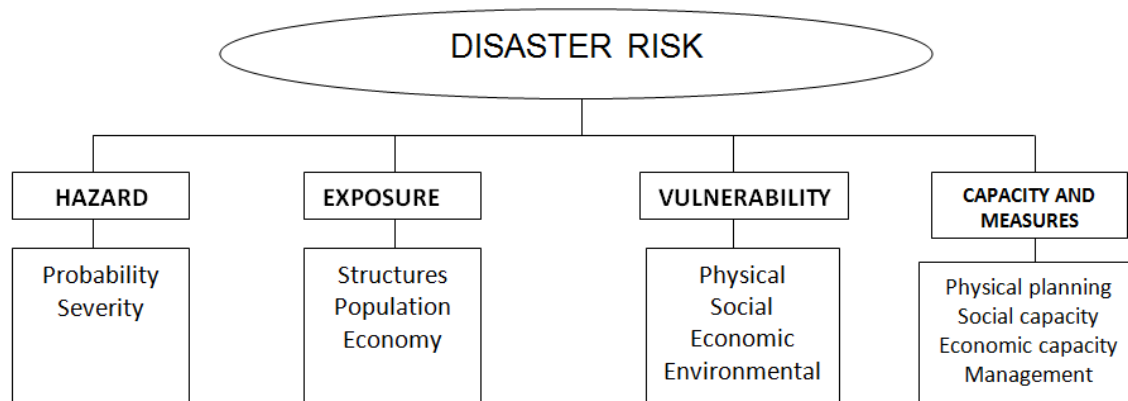


Figure 3. Conceptual Framework to Identify Risk²⁷

Even higher risks are incurred by networks of networks or those that combine different kinds of systems. Emergency management is an example of a network of networks, causing an increase in risk as the disaster becomes more complex.²⁸ Using Figure 3 as an example, emergency management is a system involving hazard, exposure, vulnerability, and adaptive capacity. These four areas intersect multiple social and technical systems within emergency management that interrelate to solve complex problems. This “network of networks” can create increased risk overall. However, by identifying areas where 1) hazards may be mitigated, 2) exposure may be limited, 3) vulnerability may be reduced, and/or capacity can be improved, the overall risk can be decreased.²⁹

²⁷ Ciurean, Schroter, and Glade, “Conceptual Frameworks of Vulnerability.”

²⁸ Naim Kapucu, and Vener Garayev, “Designing, Managing, and Sustaining Functionally Collaborative Emergency Management Networks,” *The American Review of Public Administration*, 43 (2012): 312. doi:10.1177/0275074012444719.

²⁹ Ciurean, Schroter, and Glade, “Conceptual Frameworks of Vulnerability,” 9.

The word “resilience” is used by many as a catch-all phrase for a community’s capacity to recover. The root of the word comes from the Latin word “resilio,” which literally means to “jump back.”³⁰ The dictionary definition is quite similar, stating that resilience is the “power or ability to return to the original form or position, or the ability to recover readily.”³¹ In physics, the term refers to the speed at which a material or system returns to equilibrium after displacement.³² These definitions all outline a concept of being able to absorb a shock (disaster) and return to original form (see Figure 4).³³

By its nature, resilience is a reactive concept.³⁴ It focuses on the community after a disaster, not before. This does not mean that the term is not a positive concept. The ability to withstand shocks and quickly return to a sense of normal following a disaster is incredibly important for a community. Yet, the concept of resiliency alone does not resolve systemic failures and does not decrease the overall risk to communities in disaster areas.

Resilience: The ability of a system to return to its original form or position, or the ability to recover quickly.

Figure 4. Thesis Definition of Resilience

1. Community

In the *Handbook of Disaster Research*, it defines emergency management as, “the discipline and profession of applying science, technology, planning, and management to

³⁰ Gian Paolo Cimellaro, Andrei M. Reinhorn, and Michel Bruneau, “Framework for Analytical Quantification of Disaster Resilience,” *Engineering Structures* 32, no. 11 (2010): 3639–3649.

³¹ *Dictionary.com*, s.v. “Resiliency,” accessed December 27, 2014, <http://dictionary.reference.com/browse/resiliency?s=t>

³² Fran Norris et al., “Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness,” *American Journal of Community Psychology* 41 (2007): 129.

³³ National Research Council of the National Academies, *Applications of Social Network Analysis for Building Community Disaster Resilience: Workshop Summary* (Washington, DC: National Academies Press, 2009), 23.

³⁴ Siambabala Bernard Manyena, “The Concept of Resilience Revisited,” *Disasters* 30, no. 4 (2006): 438, doi:10.1111/j.0361-3666.2006.00331.x.

deal with extreme events that can injure or kill large numbers of people, do extensive damage to property, and disrupt community life.”³⁵ In order for emergency managers to work within these parameters, they cannot work alone, in one department or jurisdiction. Emergency managers must depend upon the various communities who may be able to offer support and assistance in accomplishing disaster related goals.

When most people think of the word “community,” they see a vision of people working together in a specific geographic area, sharing common interests or needs. In addition, the term has also been used to describe almost any collection of individuals, whether they are governmental, non-governmental, political, professional, social, ethnic, or religious. For example, in one municipality, there may be a church, a university, an apartment complex, a subdivision, a political headquarters, and a real estate association. Each of these alone could be considered a community.³⁶

Another view of community involves the notion of competing interests where various groups negotiate with each other over power and influence, leading to a disproportionate distribution of risk. Therefore, community can be characterized by both consensus as well as conflict. Current research indicates that this is a factor in whether a community is able to recover from disaster.³⁷

Therefore, the idea of community goes beyond any one geographic limit or social, political, or religious construct. It is also more than the sum of its parts or its individual members. In the book, *The Different Drum: Community Making and Peace*, Scott Peck uses the analogy of a gem to better define the complexities of community. Much like a gem, in order to understand the community, one must understand all of its facets, each of which is one mere part in the whole.³⁸

³⁵ William A. Anderson, Patrick J. Kennedy, and Everett Ressler, “From Research to Praxis: The Relevance of Disaster Research for Emergency Management,” in *Handbook of Disaster Research*, ed. Havidan Rodriguez, Enrico L. Quarantelli, and Russell Dynes (New York: Springer, 2007), 468.

³⁶ Morgan Scott Peck, *The Different Drum: Community Making and Peace*, 2nd ed. (New York: Touchstone, 1998), 1.

³⁷ Anderson, Kennedy, and Ressler, “From Research to Praxis,” 468.

³⁸ Peck, *The Different Drum: Community Making and Peace*, 1.

In order to use the term “community” for the purposes of this research, it must be restricted to the confines of emergency management (see Figure 5). Researchers at the Disaster Research Center have categorized all governmental and non-governmental organizations into four basic categories: 1) established, 2) expanding, 3) extending, and 4) emergent organizations.³⁹ According to the same researchers, established and expanding organizations already have disaster-related tasks on a daily basis and merely expand their responsibilities depending upon the size of the disaster. These may include governmental structures such as emergency management organizations, fire departments, law enforcement, emergency medical services, and hospitals. They may also include non-governmental organizations, such as the American Red Cross or the Salvation Army. Extending groups do not have a day-to-day disaster mission, but they have been involved in disaster-related planning and preparedness activities, which may include construction companies or debris removal companies that are integral to an effective disaster response and recovery. It also includes homeowners associations, faith-based groups, and community organizations that work together on a regular basis. Finally, emergent groups are those that have no prior formal structure but come together for a disaster-related purpose. This group includes unaffiliated volunteers who flock to a disaster scene and provide a variety of services to the affected area.⁴⁰

Community: Unified groups of individuals with a common purpose before, during and after emergencies and disasters

Figure 5. Thesis Definition of Community

Established, expanding, and extending groups can all be considered communities within the emergency management realm. Each has a defined group of people that share a common goal or purpose and each is well established prior to a disaster. Due to the nature of emergent groups, however, they are not typically considered a community pre-disaster.

³⁹ Anderson, Kennedy, and Ressler, *From Research to Praxis*,” 472.

⁴⁰ Ibid.

Therefore, for purposes of this research, community will be defined as those unified groups of individuals with a common purpose before, during, and after emergencies and disasters. This may include governmental and non-governmental partners as well as community organizations, such as faith-based groups, homeowners associations and geographic communities with no formal authority or government structure.

2. Fragility

The term community fragility is the main focus of this paper. This term is much less used in the emergency management field, but it accurately portrays the notion of decreasing community risk both before and after disaster by looking at individual points of weakness that may lead to systemic failures (see Figure 6). The dictionary defines fragile as “easily broken, shattered or destroyed.”⁴¹ When discussing fragile states from an international perspective, the term fragility is used to describe a point of failure or the risk of failure for a community within a nation state.⁴² In architectural terms, based on earthquake fragility, the term is used much in the same way to describe a point of failure or the probability of failure to a building.⁴³

Fragility: A quality that leads to weakness or failure within a system, sometimes resulting in cascading effects (the domino) that can lead to systemic failures and collapse

Figure 6. Thesis Definition of Fragility

⁴¹ *Dictionary.com*, s.v., “Fragility,” accessed December 27, 2014, <http://dictionary.reference.com/browse/fragility?s=t>

⁴² Patrick Guillaumont and Sylviane Guillaumont Jeanneney, “State Fragility and Economic Vulnerability: What Is Measured and Why?” Development and Cooperation—EuropeAid, accessed December 27, 2014, https://ec.europa.eu/europeaid/erd-2009-background-paper-state-fragility-and-economic-vulnerability-what-measured-and-why-patrick_en, 12–14.

⁴³ Bruce R. Ellingwood, Ozan Cem Celik, and Kursat Kinali, “Fragility Assessment of Building Structural Systems in Mid-America,” *Earthquake Engineering & Structural Dynamics* 36, no. 13 (2007): 1936.

Two areas of emphasis are important in determining the degree and measurement of fragility for the emergency management field. The first is a point of weakness that may cause a failure. For example, in the *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, the cause of the shuttle explosion was found to be “a failure in the joint between the two lower segments of the right Solid Rocket Motor.” The report goes on to state that no other part of the shuttle system contributed to the failure.⁴⁴ This incident involved one point of weakness that caused the shuttle system to become fragile and fail.

The second area of emphasis involves more complexity, where the accumulation of small failures build up and result in systemic failures. This is often called a “tipping point” where individually, these areas of fragility would not cause extensive harm, but collectively they take the system to a point where it is unable to function and it fails.⁴⁵ Continuing with the example of a space shuttle, this collective series of failures can be adequately shown in the space shuttle *Columbia* disaster in 2003. In a report by Marcia S. Smith titled, *NASA’s Space Shuttle Columbia: Synopsis of the Report of the Columbia Accident Investigation Board*, the Columbia Accident Investigation Board (CAIB) concluded that a series of failures occurred that ultimately caused the shuttle disaster.⁴⁶ A root cause analysis shows the cascading events that caused this tragedy: 1) The orbiter disintegrated, due to 2) a left wing structural failure, due to 3) the shuttle’s weakened state after extreme heat and velocity in re-entry, due to a hole that was created in the wing due to 4) a 1.7 pound piece of foam that struck it just after liftoff.⁴⁷ On the surface, it seems that the 1.7 pound piece of foam that separated from the external tank caused this

⁴⁴ U.S. Government Printing Office, *Report of the Presidential Commission on the Space Shuttle Challenger Accident* (Washington, DC: U.S. Government Printing Office, 1986), Chapters III and IV.

⁴⁵ Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (Boston: Back Bay Books, 2002).

⁴⁶ Marcia Smith, *NASA’s Space Shuttle Columbia: Synopsis of the Report of the Columbia Accident Investigation Board* (Washington, DC: Congressional Research Service, 2003), <http://history.nasa.gov/columbia/Troxell/Columbia%20Web%20Site/Documents/Congress/CRS%20Summary%20of%20CAIB%20Report.pdf>

⁴⁷ Ibid.

disaster.⁴⁸ But upon further analysis, if that piece of foam had not hit the left wing causing a hole, then the superheated air would not have been able to disintegrate the left wing upon re-entry, ultimately leading to the destruction of the shuttle as a whole. Additionally, the *Columbia Accident Investigation Report* found that a “culture” of neglect and shortcuts led to ignored warnings about the problem with the foam in the first place. All of these factors played a role in the ultimate destruction of the shuttle and led to the loss of lives of the seven astronauts onboard the aircraft.⁴⁹

Since fragility is not well used in the emergency management field, both individual and systemic weaknesses and failures will be used to determine fragility. Therefore, for purposes of this research, fragility is defined as a quality that leads to weakness or failure within a system, sometimes resulting in cascading effects (the domino) that can lead to systemic failures and collapse.

3. Community Fragility

Community fragility is explored as a network, or system of systems. For example, a homeowners association may not be a formal government structure, but it ties a group of people together for a common purpose and can either increase or decrease fragility before, during, or after a disaster (see Figure 7).

Community Fragility: A quality that leads to weakness and possible failure within a “system of systems” which connects emergency management and an affected community

Figure 7. Thesis Definition of Community Fragility

Additionally, an emergency management system is not tied together through government but through a common understanding of the needs of the environment around them. Government structures also play a key role in the definition of community fragility.

⁴⁸ “Root Cause Analysis: The Space Shuttle Columbia Disaster,” ThinkReliability, 2014, <http://www.thinkreliability.com/cm-columbia.aspx>

⁴⁹ National Aerospace and Security Administration, *Report of Columbia Accident Investigation Board*, Vol. 1, 2003, http://history.nasa.gov/columbia/Troxell/Columbia%20Web%20Site/Documents/Congress/House/SEPTEM~1/executive_summ.html

Loosely formed governments, such as special districts or tax-based entities providing a service, play a role as surely as do the more formal municipal, county, state, and federal institutions.

Each of these groups, or social systems, will have a direct effect on the response and recovery from a disaster. If failures occur within the network of people or groups, or a series of failures occur, it will affect the whole. If the fragility of the community could be measured, however, failures may be recognized early enough to make the necessary changes to strengthen the system overall. Additionally, as we have seen in multiple recent disasters, cascading events from a disaster can be just as devastating as the original event. Through a study of community fragility, mitigation measures may be better established to decrease the dangers associated with disaster and in effect, decrease or eliminate the catastrophic cascading events that follow.

C. PART II: STUDIES IN FRAGILITY AND THEIR APPLICATION TO EMERGENCY MANAGEMENT

A vast amount of research is available in the emergency management field regarding community resiliency and vulnerability, specifically with regard to hazard assessments and recovery procedures. However, the topic of fragility is relatively new to emergency management and homeland security, and the further defined idea of community fragility is even less studied. Therefore, several areas of fragility were explored in this research to determine basic commonalities.

A recent trend in the field of emergency management involves a “whole community” approach to disaster preparedness and response. According to the Federal Emergency Management Agency,

We must leverage all of the resources of our collective team in preparing for, protecting against, responding to, recovering from and mitigating against all hazards; and collectively we must meet the needs of the entire community in each of these areas.⁵⁰

⁵⁰ Federal Emergency Management Agency, “Whole Community Engagement,” 2014, <https://www.fema.gov/whole-community>

This suggests that in order for emergency management to be effective, the field must expand and include various community components, including community organizations, non-profits, businesses, the private sector, and other key groups within the area served by the emergency management organization. Since community fragility is defined as a system of systems, it must be researched in a holistic fashion, which includes formal emergency management and governance structures as well as informal community structures and social norms. This has the potential to provide a broader picture of the complexities involved in managing these large-scale disasters and allow emergency managers the ability to solve problems otherwise unknown when studying each individual system on its own.

The majority of the literature on fragility and/or community fragility is based upon research in complex social, technical, and biological networks. Accordingly, the remainder of this section is broken down into sub-sections in each of these areas. Additionally, each section provides first a review of the literature available on fragility, and the application of that literature to the conceptual development of fragility in emergency management.

D. ECOLOGICAL SYSTEMS AND FOOD WEB NETWORKS

A large amount of research available regarding the topic of fragility exists in the study of ecological systems and food web networks.⁵¹ Food webs consist of networks of food chain relationships in ecosystems and provide a complex picture of species interaction, diversity, structure and function.⁵² Complex food web networks, such as rainforests and coral reefs, often appear more stable than less complex systems. In a complex systems group project published by the Santa Fe Institute, Institute of Theoretical Physics, and the Chinese Academy of Sciences, the authors argue that although stability does not typically correspond to complexity in mathematical models,

⁵¹ Ricard V. Solé and Jose M. Montoya, "Complexity and Fragility in Ecological Networks," *Proceedings of the Royal Society: Biological Sciences* 268, no. 1480 (October 2001): 2039, doi:10.1098/rspb.2001.1767.

⁵² Jennifer A. Dunne, Richard J. Williams, and Neo D. Martinez, "Food-Web Structure and Network Theory: The Role of Connectance and Size," *Proceedings of the National Academy of Sciences of the United States of America* 99, no. 20 (October 1, 2002): 12917, doi:10.1073/pnas.192407699.

this is not necessarily true for the natural world. The authors state, “In nature we deal not with arbitrary complex systems, but rather with ones selected by a long and intricate process.”⁵³ Due to these intricacies, ecological systems and the networks that connect them are studied as a first step in understanding fragility.

1. Relevant Bodies of Literature on Ecological Systems and Food Web Networks

An ecological community consists of a group of interacting or potentially interacting species that live in the same place. The community is bound together by the impacts and influences the species have on one another.⁵⁴ This level of interconnectedness leads to varying degrees of stability, where a disturbance to one species has a direct effect on all other species. Food web networks illustrate this principle at a larger level, through a series of relationships and interactions between ecosystems.⁵⁵

The review of the literature begins with species connections and the effects of loss of strong and weak species within the system. The first factor concerns the connections of the key species, often called “keystone” species, to other areas of the system, as well as the effects on the system if that species were removed. Several studies, such as that of Solé and Montoya, have found that upon the removal of the most connected species from a food web, community stability will be greatly disturbed.⁵⁶ For example, in Washington State, starfish have been known to be keystone species— the most connected within the community. Through their existence, they provide the ability for smaller species to thrive since they stave off mussels that would otherwise feed on the smaller species. Therefore, the very existence of the starfish keeps other species from extinction. Another example of the importance of the keystone species is equivalent to the role of a keystone in an arch.

⁵³ Samraat Pawar et al., *Evolution of Food-Web Networks in Fluctuating Environments* (Beijing, China: Santa Fe Institute, Institute of Theoretical Physics, and Chinese Academy of Sciences, 2005), <http://www.unm.edu/~oskar/project%20report%20CSSS05%20final.pdf>

⁵⁴ “Ecological Communities: Networks of Interacting Species,” Global Change, October 26, 2008, http://www.globalchange.umich.edu/globalchange1/current/lectures/ecol_com/ecol_com.html

⁵⁵ Dunne, Williams, and Martinez, “Food-Web Structure and Network Theory,” 12917–12922.

⁵⁶ Solé, and Montoya, “Complexity and Fragility in Ecological Networks,” 2039.

The keystone is under the least amount of pressure of any of the stones within an arch, but the arch would collapse without it.⁵⁷

A recent study suggests that weakly interacting species can also be keystone species, in the sense that their loss can have multiple consequences causing a trickle-down effect (or domino effect), which will cause dramatic changes throughout the system as a whole.⁵⁸ For example, the extinction of sea otters from the Pacific Coasts of North America led to the extinction of kelp forest communities. This was due to overgrazing of the kelp by a predator species no longer controlled by the sea otter population. Bo Ebenman and Tomas Jonsson have studied whether these results were typical or whether the phenomenon was unique to one species. They found that this phenomenon is common amongst a variety of species and that analysis can be used to identify fragile community structures and keystone species. Hence, they found this can provide management priorities for the preservation of the species.⁵⁹

The relationship between connectedness and stability is also the subject of many studies, most of which concentrate on the overall change in stability of the species' community when small disturbances are introduced. Interactions and diversity within the food web have been shown to strengthen the network as a whole.⁶⁰ Therefore, in order to maintain a robust ecological network, with the ability to adapt and the flexibility for change, must have a diverse combination of keystone species as well as weak species to optimize species interaction and decrease the possibility of species collapse or extinction.

2. Ecological Systems Literatures Applied to the Concept of Fragility in Emergency Management

The literature on ecological networks, specifically food webs, is significant to the study of fragility in emergency management in several ways. We live in a highly

⁵⁷ "Keying in on Keystone Species," Arizona State University School of Life Sciences, 2014, <https://askabiologist.asu.edu/what-keystone>

⁵⁸ Bo Ebenman, and Tomas Jonsson, "Using Community Viability Analysis to Identify Fragile Systems and Keystone Species," *Trends in Ecology & Evolution* 20, no. 10 (October 2005): 568, doi:10.1016/j.tree.2005.06.011.

⁵⁹ Ibid., 569.

⁶⁰ Pawar et al., *Evolution of Food-Web Networks in Fluctuating Environments*.

interconnected global environment, where the actions of one group have the ability to greatly affect another group or the global community as a whole.⁶¹ Furthermore, the emergency management field is also a loosely connected network of various systems and providers. For example, a bomb explosion in a crowded urban area will involve emergency services systems such as fire, law enforcement, and emergency medical services, as well as the healthcare system, intelligence community, and a series of non-governmental and private sector partners—all working in concert to mitigate the disaster. A weakness in any one of these areas could lead to an individual system failure or a cascade of events that create a failure throughout the intricate network of systems.⁶² Using the bomb example, a failure of the intelligence community to share vital information with local law enforcement may lead to a lack of surveillance, allowing the bomb to go off. Additionally, a systemic failure can be illustrated using the same example. The lack of surveillance may lead to the attacker gaining vital information and detonating a bomb in a crowded subway station, leading to a disruption in the transportation system. The explosion further affects the system by taking out the power transformer nearby, leading to a collapse of the energy transmission throughout the area, which further complicates the transportation system by disabling stoplights at key intersections. This cascade of events has the potential to go on until a full collapse of the system is seen with an increase in damage as an increase in the loss of lives.

The first consideration in the literature for ecosystems is the importance of the keystone species and the connections between the keystone species to all other parts of the ecosystem. In emergency management, the keystone species is often the local emergency manager. He or she is the most connected individual within the system before, during, and after a disaster and her or his loss could have a dramatic effect on the system as a whole. Additionally, because of the emergency manager's role as an integrator and

⁶¹ Erica P. Dalziell, and SoniaT. McManus, "Resilience, Vulnerability, and Adaptive Capacity: Implications for System Performance" (presented at the International Forum for Engineering Decision Making, Stoos, Switzerland, 2004), http://ir.canterbury.ac.nz/bitstream/10092/2809/1/12593870_ResOrgs_IFED_dec04_EDSM.pdf

⁶² William Waugh, and Gregory Streib, "Collaboration and Leadership for Effective Emergency Management," in "Effective Emergency Management: Articles of Collaborative Public Management," special issue, *Public Administration Review* (December 2006): 131–40.

coordinator between multiple groups and networks of people, he or she also shares the burden of keeping smaller groups from extinction. For example, Voluntary Organizations Active in Disaster (VOAD) would not have a means of effectively connecting into a disaster without a central coordination point such as an emergency operations center or the emergency manager. They would still function, possibly, but not effectively and their existence could actually cause harm if their activities were done in an uncoordinated manner. Additionally, without a key role in the disaster, the groups could very well break apart and cease to exist.

Another key finding in the ecological literature found that a weak species could sometimes be considered a keystone if its removal had the potential to cause systemic failures. Similar to ecological networks, studies have been conducted to determine the thresholds for individual networks to fail when specific groups or individuals are removed. How many people can be removed before the system fails as a whole? Researchers have found that with individual networks, there is a progressive decline in functionality as individuals are removed until finally a failure occurs.

From an emergency management perspective, such a phenomenon can be found in the interactions between individuals and groups during a disaster. For example, the American Red Cross is one of the primary support entities for post-disaster sheltering operations. As a non-governmental entity, it does not have the direct responsibility for sheltering people in jurisdictions. Instead, that responsibility lies with the governing authority, whether it be the municipal, county, or state government. For many jurisdictions, however, they rely heavily on the American Red Cross to support incident operations and would suffer without its support. Therefore, if the Red Cross was removed from the emergency management system, it would have the potential to cause a trickle-down effect, much like in ecosystems, where multiple other individuals and groups would be affected. For example, in the 2013 Colorado Flood event, the American Red Cross was overwhelmed with requests for shelters and evacuation points. It exceeded its capacity to respond and had to call in national resources to help manage the event.⁶³ If

⁶³ “Red Cross Responds to Colorado Flooding,” American Red Cross, September 13, 2013, <http://www.redcross.org/news/press-release/Red-Cross-Responds-To-Colorado-Flooding>

the Red Cross support had ceased during this event, it would have placed an enormous burden on the local jurisdictions to provide shelter to the thousands of displaced people in the 17 affected counties. This, in turn, would cause a strain on logistical support, human resources and on the overall prioritization of tasks for the incident. Therefore, while the American Red Cross is not considered the “keystone” in emergency management, its removal could have devastating effects.

Finally, the literature on ecological systems suggests that connectedness and stability are both key factors in the survival of ecosystems. This area of research discusses how a species community would respond when small disturbances are introduced and suggest that greater interactions and diversity lead to a stronger network overall. This ties back in to the concept of “whole community” planning and emergency management. In the 9/11 Commission Report, one of the key findings of the panel was that organizations working in silos, without the ability to share information, had a direct effect on the inability to detect and apprehend the hijackers before the attacks on September 11, 2001. The report calls for “a unity of effort” in several key areas, bringing the intelligence community, Congress, and foreign operatives together to “transcend traditional governmental boundaries.”⁶⁴ This notion of crossing boundaries and creating greater diversity in the homeland security arena has the potential to strengthen national efforts to combat terrorism. Additionally, as the literature suggests, with a more diverse network, small disturbances are easier to absorb and manage, decreasing the chance of failure in the emergency management system. See Figure 8 for an overview of the key measurements for fragility in ecological systems and food web networks.

⁶⁴ National Commission on Terrorist Attacks upon the United States, *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks upon the United States* [executive summary], http://www.9-11commission.gov/report/911Report_Exec.pdf, 21.

Measuring Fragility in Ecological Systems and Food Web Networks

- Removal of species—Removal of primary species (keystone) causes instability, removal of weaker species can also cause a trickle-down effect, which will cause changes throughout the system as a whole.
- Fragile ecosystems—The least fragile systems have a combination of weak and strong species which creates a mix of cooperation and competition.
- Diversity—Interactions and diversity strengthen the system as a whole.

Figure 8. Fragility Measurements for Ecological Systems and Food Web Networks

E. SOCIAL SYSTEMS

In the past, there has been an assumption that ecological and social systems should be treated independently, but further research confirms that both behave in a similar fashion. Each is a dynamic, nonlinear, complex, and evolving system interacting in a multitude of ways.⁶⁵ Differences between individuals create differing outcomes based upon history, culture, complexity, and individual preferences.⁶⁶ Individuals often must make decisions based upon uncertain information and future expectations. In an issues paper by Huma Haider, of the International Development Department at Birmingham University, she states, “The empowerment of local people and the perception and treatment of them as resourceful and capable can also contribute to confidence-building and feelings of worth.”⁶⁷ This allows for a great deal of innovation and improvisation when the situation warrants. In emergency situations, where the stress is high and the ability to predict outcomes decreases, individuals must depend upon these traits of flexibility and adaptability in order to survive.

In this section, social systems are explored in a few ways. The vast amount of research on fragility of social systems exists within the context of increasing or

⁶⁵ Carl Folke et al., “Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations,” *Ambio* 31, no. 5 (August 2002): 437.

⁶⁶ Helbing, “Globally Networked Risks and How to Respond,” 57.

⁶⁷ Huma Haider, *Community-Based Approaches to Peacebuilding in Conflict-Affected and Fragile Contexts* (Birmingham, England: University of Birmingham: Governance and Social Development Resource Centre, 2009), 9.

decreasing social capital, which is further divided into three primary areas of social capital: trust, social norms, and networks. Additionally, this section analyzes social cohesion and social vulnerability as concepts of fragility in social systems.

1. Relevant Bodies of Literature on Social Systems

As related to researching the key factors that may make a community more or less fragile during and after disasters, multiple studies illustrate that social capital is a primary factor. Social capital primarily consists of social norms, trust, and networks. These areas can be more specifically defined as three types of connectedness: bonding (social norms), bridging (trust), and linking (networks).⁶⁸ Bonding involves the social norms that are formed between families and communities sharing the same demographic characteristics and similar objectives. Bridging involves the capacity of groups of people from different ethnic or geographical backgrounds to make links with others that may have different views. This involves a degree of trust in order to form these relationships outside areas of comfort or influence. Finally, linking describes the ability of these various groups to communicate and work with external partners or systems. Linking involves the creation of networks between the community and formal systems, such as business or government, either to influence their policies or to utilize helpful resources.⁶⁹

a. Social Norms

Existing research suggests that there is a connection between the type and quantity of support provided by social networks and the relationships between the people within each social network. Studies have found that community ties with friends and family are the primary way through which people get the resources they need to survive. These ties make up much of the social capital people use in daily life and help people to capture opportunities and reduce uncertainty.⁷⁰ Several studies, such as one carried out

⁶⁸ Yuko Nakagawa, and Rajib Shaw, "Social Capital: A Missing Link in Disaster Recovery," *International Journal of Mass Emergencies and Disasters* 22, no. 1 (March 2004): 9. 5–34

⁶⁹ Jules Pretty, "Social Capital and the Collective Management of Resources," *Science (New York, N.Y.)* 302, no. 5652 (2004): 1912, doi:10.1126/science.1090847.

⁷⁰ Barry Wellman, and Scot Wortley, "Different Strokes from Different Folks: Community Ties and Social Support," *American Journal of Sociology* 96, no. 3 (November 1, 1990): 558.

by Hayden, have found that community ties are not only dependent upon the interactions of people with one another, but also on the personal characteristics of those involved and the overall cultural and belief systems that create social norms. Moreover, researchers have also shown that a tie between two people does not necessarily mean that a support structure exists.⁷¹ Instead, the individuals that make up the community are equally important to the structure of the social network that determines what happens within the community. For example, teams are created from both the individual strengths of the athletes as well as how they all work together.⁷² Research shows that a well-established personal community network depends upon a set of active community ties, including a diverse group of people, throughout a large area with loose connections.⁷³

Research regarding social norms also suggests that the size of the social network is important. Several studies show that larger networks tend to be more supportive,⁷⁴ similar to the high connectedness found in food web networks. Researchers, such as Wasserman and Galaskiewicz, have also found that the larger the network, the higher the percentage of people within the network that provide support. Therefore, not only do they have more support systems to choose from, but communities also have more members within each network to support.⁷⁵ However, the downside of a larger network is that if people perceive inequalities in the amount of support, it may lead to the destruction of the ties that hold those groups together.⁷⁶

⁷¹ Nancy Hayden, *Dynamic Social Network Analysis: Present Roots and Future Fruits* (Washington, DC: Defense Threat Reduction Agency, Advanced Systems and Concepts Office, 2009), <https://info.publicintelligence.net/DTRA-SocialNetworkAnalysis.pdf>, 12.

⁷² Ibid., 6.

⁷³ Wellman, and Wortley, "Different Strokes from Different Folks," 559.

⁷⁴ Stanley Wasserman, and Joseph Galaskiewicz, eds., *Advances in Social Network Analysis: Research in the Social and Behavioral Sciences* (Thousand Oaks, CA: Sage Publications, Inc., 1994), 62.

⁷⁵ Ibid.

⁷⁶ Ibid., 64.

b. Trust

The topic of trust has been heavily researched at multiple levels, including personal trust, organizational trust, and societal trust.⁷⁷ For example, Kurt T. Dirks and Donald L. Ferrin have studied trust and its role in fostering cooperation, high performance, and positive attitudes. Their study concluded that it is likely that trust would facilitate stronger cooperation because, with a high degree of trust, individuals believe that others are willing to cooperate.⁷⁸ Other studies have attempted to better define what causes trust to exist in the first place. For example, is trust merely based upon the possible cost or benefit of an interaction, or is trust established through multiple interactions over time? Studies have adequately shown that both of these are indicators of trust. Therefore, the argument can be made that trust is established when a benefit can be clearly illustrated and is strengthened with multiple interactions over time.⁷⁹

Trust has also been shown in studies to increase the ability of partners to innovate and make decisions in a non-linear fashion, leading to a more dynamic response.⁸⁰ The assumption is that this approach has been so successful because social capital is strongest at the local level, specifically with regard to trust. One research paper on building trust in economic exchange, confirms this assumption through an examination of various studies about the formation of trust. The author, Peter Ring, evaluates the definition of trust as, “a noncalculative reliance in the moral integrity, or goodwill, of others on whom economic actors depend for the realization of collective and individual goals when they deal with future, unpredictable issues.”⁸¹ At the local level, there is more of an opportunity to understand and rely upon the moral integrity or goodwill of others because the people have interacted more frequently.

⁷⁷ Thomas J. Currao, “A New Role for Emergency Management: Fostering Trust to Enhance Collaboration in Complex Adaptive Emergency Response Systems” (master’s thesis, Naval Postgraduate School, 2009), 11.

⁷⁸ Ibid., 5.

⁷⁹ D. Harrison McNight, Larry Cummings, and Norman Chervany, “Initial Trust Formation in New Organizational Relationships,” *Academy of Management Review* 23, no. 3 (July 1998): 473.

⁸⁰ Currao, “A New Role for Emergency Management,” 5.

⁸¹ Peter Smith Ring, “Fragile and Resilient Trust and Their Roles in Economic Exchange,” *Business & Society* 35, no. 2 (June 1996): 156, doi:10.1177/000765039603500202. 148–75.

c. Social Cohesion and Vulnerability

Social cohesion is defined as the ability of a community to ensure the welfare of its members, which minimize inequalities and social division.⁸² This includes leadership, community organization, networks, and social capital. There is a vast amount of literature that suggests that a lack of social cohesion between groups contributes to a decrease in trust and the increase of fragility of formal institutions, and that social cohesion can contribute to stability.⁸³

The area most studied with regard to social cohesion and fragility involves the study of fragile nation states. State fragility has been associated with a variety of factors, including: low capacity due to a lack of financial, physical or human resources; poor governance and/or corruption; failure to deliver services that meet basic human needs; and low levels of social cohesion.⁸⁴ A Canadian Team working for the Foreign Affairs Ministry found similar results in their study where they identified three specific areas where state fragility is measured. These include authority failure, service entitlement failure and legitimacy failure. Authority failures come from civil conflict or violence, service entitlement failures come from human development outcomes such as poverty rates and childhood mortality, and legitimacy failures are measured by the level of democracy or level of autocracy.⁸⁵ The researchers found that there is little correlation between these three factors, meaning that failing countries rarely did not have to have two or more to fail. Therefore, by using the definition of fragility as the risk of failure of a nation state, any one of these factors is important individually.

Some of the key factors of social vulnerability available in recent studies are similar to those found in fragile nation states. They include: access to resources (including information and technology); access to political power or representation;

⁸² “State Fragility and Social Cohesion,” accessed December 27, 2014, http://www.academia.edu/5313761/State_fragility_and_social_cohesion

⁸³ Ibid., 3.

⁸⁴ Bilal Barakat, Zuki Karpinska, and Julia Paulson, “Desk Study: Education and Fragility” (presented at INEE Working Group on Education and Fragility, April 2008), http://www.ineesite.org/uploads/files/resources/doc_1_FINAL-Desk_Study_Education_and_Fragility_CERG2008.pdf, 2.

⁸⁵ Guillaumont, and Jeanneney, “State Fragility and Economic Vulnerability,” 10.

social capital; limited access and functional needs, and the accessibility of lifelines such as power, water, and road systems.⁸⁶

2. Social Systems Literatures Applied to the Concept of Fragility in Emergency Management

Social systems are an integral part of any emergency management system. Every disaster is directly affected by the people involved, either through the affected community or the emergency responders that come to assist. An evaluation of the research on the fragility of social systems brought to light several key concepts for emergency management.

The studies on social capital clearly illustrate that the development of social capital involves a participative community, where citizens are engaged and active in community activities.⁸⁷ In an article for the *International Journal of Mass Emergencies and Disasters*, Yuko Nakagawa and Rajib Shaw state, “A high accumulation of such capital contributes significantly to social, political and even economic performance, for better or worse.”⁸⁸ This allows people affected by disaster to go from being mere victims to survivors, and possibly the creators of a more robust community in the future. As Russell Dynes explains, “Even with losses to physical and human capital, social capital is less affected, can be quickly repaired, and provides an essential resource in accomplishing critical tasks.”⁸⁹

a. Social Norms

Social norms are a powerful form of social capital that will either enable action or limit action by community members, emergency managers, and government officials. The research on social norms clearly shows that community ties are the primary way in

⁸⁶ Susan Cutter, Bryan Boruff, and W. Lynn Shirley, “Social Vulnerability to Environmental Hazards,” *Social Science Quarterly* 84, no. 2 (June 2003): 245.

⁸⁷ Jenny Onyx, and Paul Bullen, “Measuring Social Capital in Five Communities,” *The Journal of Applied Behavioral Science* 36, no. 1 (March 2000): 25, doi:10.1177/0021886300361002.

⁸⁸ Nakagawa, and Shaw, “Social Capital,” 6.

⁸⁹ Russell Dynes, “Social Capital: Dealing with Community Emergencies,” *Homeland Security Affairs* II, no. 2 (July 2006): 2.

which individuals get information. When lacking relevant information from a broad perspective, individuals will make decisions that may make sense at a smaller level but could conflict with broader community needs.⁹⁰ In situations where information is available and collective action is needed, however, individuals will often act as a unit for the greater good of the whole. In a research paper analyzing Eric Posner's law and social norms, Dan Kahan, from Yale Law School, states that studies consistently show that individuals in collective action settings, such as a disaster, will often adopt a cooperative attitude and will contribute to the collective good if they perceive that others may do the same.⁹¹

One other factor included in whether social norms affect community fragility involves cultural and belief systems. This is largely why a disaster in the southern United States will have different characteristics than one in the Midwest or on the East Coast. One of the key tasks of any emergency manager is to learn the community structure and diversity to better be able to communicate and coordinate during and after disasters. In different locations, there will be varying levels of communication and differing channels used to convey important messages to ensure everyone gets the information that is needed. Russell Dynes believes this trend will only continue as recent census results illustrate a widening gap between diverse groups of the United States population, leading to a need for more avenues of communication for different social networks.⁹²

The structure of networks within social systems also illustrates that larger, more diverse networks are less fragile to shocks and disturbances overall. In emergency management, this can be illustrated through the large networks of non-profit and non-governmental entities that assist after disasters. The larger and more diverse the network of providers of service, the better able members of the community are able to find the services they need.

⁹⁰ Louise K. Comfort, "Rethinking Security: Organizational Fragility in Extreme Events," *Public Administration Review* 62 (2002): 101, doi:10.1111/1540-6210.62.s1.18.

⁹¹ Dan Kahan, "Commentaries on Eric Posner's Law and Social Norms: Signaling or Reciprocating? A Response to Eric Posner's Law and Social Norms," *Litigation Essentials* 36 (May 2002).

⁹² Dynes, "Social Capital: Dealing with Community Emergencies," 9.

b. Trust

Trust is a primary factor in whether a community will hold together during and after an emergency or fall apart into chaos. This was seen clearly during Hurricane Katrina, for example, where the natural disaster quickly turned into a social disaster, leading to an increase in crime and a decrease in compliance with social norms.⁹³

Measurements of trust, at both the local community level as well as more formal levels (trust in government) can be seen in civic involvement, volunteerism, cooperative agreement, and community activities.⁹⁴ In an article by William Waugh and Gregory Streib, they state, “Emergency management capacity is built from the ground up. Neighborhood and community programs have to stand on their own because assistance may not arrive for hours or days.”⁹⁵

In Thomas J. Currao’s thesis on collaboration in complex adaptive systems, he notes, “The idea of not knowing each other diminishes the level of inter-organizational trust, which has a negative impact on emergency management operations and the ability to collaborate.”⁹⁶ Inclusive processes have the potential to strengthen community trust and practices, thereby increasing the ability of the community to work together through response and recovery activities. Strong social capital is as a way to decrease community fragility outlined in several research studies.⁹⁷

c. Social Cohesion and Vulnerability

Social inequalities often lead to social vulnerability. This involves the degree to which social factors influence the susceptibility of groups to injury or harm and the ability of those groups to adequately respond. Social vulnerability also involves “place

⁹³ Kristina M. Cordasco et al., “‘They Blew the Levee’: Distrust of Authorities among Hurricane Katrina Evacuees,” *Journal of Health Care for the Poor and Underserved* 18, no. 2 (May 2007): 277, doi:10.1353/hpu.2007.0028 ,

⁹⁴ Daniel Aldrich, “Fixing Recovery: Social Capital in Post-Crisis Resilience,” Department of Political Science Faculty Publications, Paper 3, Purdue, May 2010, <http://docs.lib.purdue.edu/pspubs/3>

⁹⁵ Waugh, and Streib, “Collaboration and Leadership for Effective Emergency Management,” 133.

⁹⁶ Currao, “A New Role for Emergency Management,” 75.

⁹⁷ Haider, *Community-Based Approaches to Peacebuilding*, 7.

inequalities,” which are those characteristics of communities based upon their location and environment, such as isolation in the case of mountain communities or the level of urbanization in cities.⁹⁸ As illustrated previously, studies consistently show that an increase in social cohesion leads to a less fragile system and an increase in the ability of the community to respond and recover.⁹⁹ This leads to a different way of looking at emergency management activities prior or a disaster. If both social cohesion and a decrease in social vulnerability will lead to stronger, less fragile emergency management systems, emergency managers can change their preparedness activities to heighten these areas. In recent years, the “whole community” approach to emergency management has attempted to narrow this gap by emphasizing all members of the community in preparedness, response, and recovery activities.¹⁰⁰ Prior social science disaster research has also recognized the community nature of emergency management and recommendations have been made for the consideration of greater community work in studying and designing emergency management programs.¹⁰¹ See Figure 9 for an overview of the key factors involved in fragility in social systems.

⁹⁸ Cutter, Boruff, and Shirley, “Social Vulnerability to Environmental Hazards,” 243.

⁹⁹ Guillaumont, and Jeanneney, “State Fragility and Economic Vulnerability.”

¹⁰⁰ Wendy Schafer et al., “Emergency Management Planning as Collaborative Community Work : Journal of Homeland Security and Emergency Management,” *Journal of Homeland Security and Emergency Management* 5, no. 1 (March 2008), <http://www.degruyter.com/view/j/jhsem.2008.5.1/jhsem.2008.5.1.1396/jhsem.2008.5.1.1396.xml>

¹⁰¹ Ibid.

Measuring Fragility in Social Systems

- Empowering citizens—Contributes to confidence and feelings of worth, decreasing fragility in the community
- Community ties—Connections with friends and family are the primary ways in which people get the resources they need to survive
- Larger networks—More supportive and better able to find needed resources, less fragile to shocks and disturbances
- Social cohesion—A lack of social cohesion leads to a decrease in trust and increase in community fragility
- Social capital—High degree of social capital contributes significantly to social, political and even economic performance, including active participation in community activities, higher cooperation with formal emergency response systems, and higher level of trust
- A high level of trust leads to better cooperation and coordination
- Resilient systems—Better able to absorb shocks and are better able to reorganize and learn during dramatic events
- Basic human needs—Ability to meet basic needs decreases stress and increases the ability to cope, decreasing the fragility of communities and systems

Figure 9. Fragility Measurements in Social Systems

F. SOCIO-TECHNICAL SYSTEMS / NETWORKS

General systems theory has been in existence for centuries. Aristotle defined a system as “a whole composed by parts in a purposeful way.”¹⁰² He also classified systems through natural phenomena, such as solar systems, as well as through societies, buildings, and machines. The original notion of socio-technical systems was first introduced in the 1950s in a series of labor studies at the Tavistock Institute in London. The concept was developed to highlight the necessary interconnections between people and machines. Researchers found that people did not follow the rigid mechanistic view of work. Instead, they found that the social aspects were also important, specifically with regard to how teams interacted, cooperated and collaborated. The performance of a system was based upon the ways in which people worked with one another and the interactions of the system as a whole. This theory led to practices utilizing more

¹⁰² Günter Ropohl, “Philosophy of Socio-Technical Systems,” *Society for Philosophy and Technology* 4, no. 3 (1999), http://scholar.lib.vt.edu/ejournals/SPT/v4_n3html/ROPOHL

flexibility, diversity, innovation and an open mind in the design of work processes and procedures.¹⁰³

This idea, similar to Aristotle's observations regarding complex system interactions, outlines the importance of analyzing social systems in the context of their interactions with other systems, or the networks connecting systems. Networks, as used in research literature, are defined as, "multi-organizational arrangements for solving problems that cannot be achieved, or achieved easily, by single organizations."¹⁰⁴ This definition is helpful in the study of emergency management, as each disaster offers varying levels of cohesion and cooperation. For example, the healthcare system relies heavily upon the emergency medical system which relies upon law enforcement and fire systems in emergency response operations. Each of these is connected through networks of partners working together. This multi-disciplinary approach outlines the key principles of socio-technical systems, which stress interaction amongst partners throughout a network of people and technical systems.

1. Relevant Bodies of Literature on Socio-Technical Systems / Networks

The Resilience Multidisciplinary Center for Earthquake Engineering Research (MCEER) has identified four properties that can be used in all systems to measure their fragility. These include:

- Robustness—the ability to withstand an event without significant disruption in service
- Resourcefulness—the capacity to apply measures to address disruptions when they do occur
- Redundancy—the ability to satisfy all system requirements with backup systems and processes, limiting disruption and downtime
- Rapidity—the ability to restore systems in a timely manner¹⁰⁵

¹⁰³ Ibid.

¹⁰⁴ Beryl A. Radin, and Joshua M. Chanin, *Federal Government Reorganization: A Policy and Management Perspective*, 1st ed. (Sudbury, MA: Jones & Bartlett Learning, 2008).

¹⁰⁵ Naim Kapucu, "Interorganizational Coordination in Dynamic Contexts: Networks in Emergency Management," *Connections: Journal of International Network for Social Network Analysis* 26 (2005): 37.

Using these properties as an organizational tool, the remainder of this section focuses on these four areas in determining what literature exists regarding systems fragility.

a. Robustness

A key factor in the formation of networks that have the ability to either increase or decrease fragility involves the actual structure of the networks. Research by Gustav Koehler, Guenther Kress, and Randi Miller finds that the more diverse a group of people, or network, the better able they are to predict variances in outcomes and come up with viable solutions.¹⁰⁶ In order to do this effectively, links must be formed between the various systems of support entities. Different ties within a network of people will provide different levels and types of support.¹⁰⁷

Many research studies suggest the importance of strong ties between each of these networks in order to ensure adequate information exchange and effective response during disaster. Much like the examples shown in the ecological system studies for individuals, however, it is equally important to look at the weak ties that bind groups together in determining how fragile they are to disturbance (see Figure 10). In studies conducted by Mark Granovetter, he found that when a network consists of merely strong ties, or groups that are closely connected, most individuals receive the same set of information from multiple sources. In contrast, when weak ties, or outlying groups, are part of the network, they provide new information previously unknown to the core group.¹⁰⁸ Because different phases of a disaster require varying levels of information, equipment, and support, it makes sense that a network of both strong and weak ties would decrease fragility of the network overall.

¹⁰⁶ Koehler, Kress, and Miller, *What Disaster Response Management Can Learn*.

¹⁰⁷ Wasserman, and Galaskiewicz, *Advances in Social Network Analysis*, 54.

¹⁰⁸ Stephen P. Borgatti et al., "Network Analysis in the Social Sciences," *Science* 323, no. 5916 (February 13, 2009): 893, doi:10.1126/science.1165821, 8.

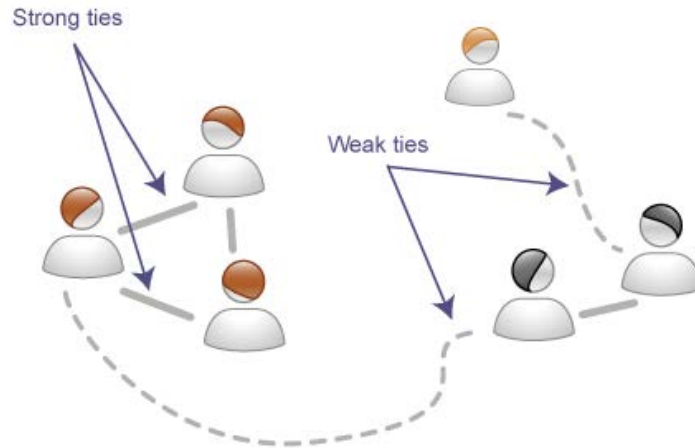


Figure 10. Diagram of the Connections between Strong and Weak Ties within a Network¹⁰⁹

b. Resourcefulness or Capacity

With regard to fragile nation states, several studies have shown adequate support involves a complex flow of resources between a wide range of partners and stakeholders. *The Catastrophic Annex to the National Response Plan* (NRP) describes the qualities of a catastrophic event from the viewpoint of the demand it places upon the emergency management system and the capacity of that system to respond.¹¹⁰

Louise Comfort, Kilkon Ko, and Adam Zagorecki conducted a study attempting to simulate an increase in demand during disaster with a decrease in capacity to determine the point at which a system would fail, thus defining the fragility of the system. According to the authors, “Modeling the fragility of sociotechnical response systems is critical to enabling metropolitan regions to manage their exposure to risk more efficiently and effectively.”¹¹¹ Public and private officials with the responsibility for the protection of community members are often unable to effectively monitor the

¹⁰⁹ Andrew Filey. “Project Management Software, Mind Mapping, Weak Ties and the Human Brain,” Wrike, July 28, 2008, <https://www.wrike.com/blog/project-management-software-mind-mapping-weak-ties-and-the-human-brain/>

¹¹⁰ Harrald, “Agility and Discipline,” 258.

¹¹¹ Louise K. Comfort, Kilkon Ko, and Adam Zagorecki, *Modeling Fragility in Rapidly Evolving Disaster Response Systems* (Berkley, CA: Institute of Governmental Studies, 2003), <http://escholarship.org/uc/item/1cz8w6gk>

interdependent interactions between organizations. In addition, they are unable to effectively share information about emerging threats real-time due to the speed of information during an event.

Therefore, the Comfort, Ko, and Zagorecki created a theoretical model to observe the changing relationship between partners as the demand for resources grew and the capacity to respond to needs diminished. They also used network theory from the field of mathematics to formalize the interaction of the various players within any emergency management system. They were able to show that different phases of emergencies require different types of management skills. Additionally, their research illustrated that failure in one area of disaster response leads to the failure in other parts of the system, which leads to a decrease in performance and possible collapse, much like the domino effect seen in ecological food webs.¹¹² However, the most interesting finding in research of Comfort, Ko, and Zagorecki was the realization that the increase in partners and interconnections during disaster response does not lead to a decrease in efficiency or fragility. Instead, networks with more connections also have more diversity and the ability to withstand and react to disturbances.¹¹³

This leads to the difference between a connected community and an interdependent community. The interdependence of systems is not directly related to the number of connections between them. Instead, interdependency is measured by how one action or disturbance will affect another. Most communities do not have well-connected systems of partners. If interdependencies exist, however, then each is sensitive to disruptions or shocks that occur to any one of the disciplines, leading to unintended consequences, unpredictability, and cascading failures.¹¹⁴ The findings of this study parallel the ecological food web research and socio-technical research regarding strong and weak ties within networks.

¹¹² Ibid., 3.

¹¹³ Ibid.

¹¹⁴ Ibid., 5.

c. Redundancy

The interdependence of systems leads to research based upon the central and peripheral figures within a network that provide redundancy and stability. Some studies have indicated that the most effective structure of a network is one that is centralized in nature with one influential hub or lead agency.¹¹⁵ But if these studies are examined with fragility in mind, this leads to an incredibly fragile structure. For one, the network is based upon one central figure; therefore, if that figure is removed, similar to food web networks, a cascading effect would occur, causing failures across the network.

Second, this leads to a very strong tie with one individual or agency, which could lead to a decrease in peripheral ties to outlying organizations that provide vital support to response and recovery operations. Therefore, to decrease the fragility of networks, there should be focus on both central and peripheral figures, allowing for greater diversity within the network.¹¹⁶ Tests have been conducted by Girvan and Newman to confirm this theory in food web networks as well as collaborative networks and both tests positively confirmed the benefits on such a structure.¹¹⁷ Even those researchers who suggest a strong central network, such as Harrald, have agreed that complex disasters require an open system of partners and organizations that have the ability to adapt readily to changing conditions and anticipate problems before they occur.¹¹⁸

Several models have also been constructed regarding the development of a holistic approach to systems failures, including Turner's man-made disaster model, Reason's Swiss cheese model, and Perrow's normal accident theory. All of these models are based upon the foundation that seemingly inconsequential failures within a system

¹¹⁵ Sang O. Choi, "When Practice Matters More Than Government Plans: A Network Analysis of Local Emergency Management," *Administration & Society* 37 (January 2006): 668.

¹¹⁶ Michelle Girvan, and Mark Newman, "Community Structure in Social and Biological Networks," *Proceedings of the National Academy of Sciences of the United States of America* 99, no. 12 (June 2002): 7822, doi:10.1073/pnas.122653799.

¹¹⁷ Ibid., 7825.

¹¹⁸ Harrald, "Agility and Discipline," 261.

interact and create a cascade of problems leading to full system failure.¹¹⁹ A study on crowd disasters recommends that, because of these interdependencies, and various moving parts, it is unlikely that any one person or group would have all of the knowledge necessary to avoid systemic failures.¹²⁰ Therefore, all parts of the system should be given consideration, including people, processes, procedures, technology, and community culture (see Figure 11). In this research, by Rose Challenger and Chris Clegg, they state, “New systems design should involve multiple stakeholders with a complementary range of knowledge and expertise, including end-users, managers, human resource experts, designers and clients. End-user participation in, and ownership of, systems design and implementation is critical.”¹²¹

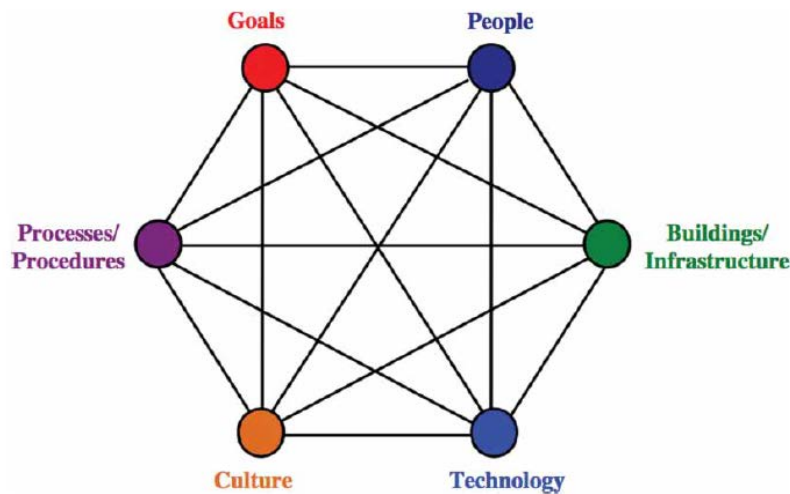


Figure 11. A Socio-Technical Systems Perspective¹²²

¹¹⁹ Rose Challenger, and Chris W. Clegg, “Crowd Disasters: A Socio-Technical Systems Perspective,” *Contemporary Social Science* 6, no. 3 (November 1, 2011): 344, doi:10.1080/21582041.2011.619862.

¹²⁰ Ibid.

¹²¹ Ibid., 345.

¹²² Ibid.

d. Rapidity

Knowing how different organizations interact with one another will provide information that is necessary to determine how information will flow within the network as well as between networks, allowing for greater flexibility and efficiency in the decision-making process. In a research paper by Naim Kapucu, he found that in a closed system, the information will be relatively stable and should be readily available to anyone in the network. In an open network, on the other hand, the information may be less stable but will be more diverse, leading to a broader perspective of the problem.¹²³ This broader perspective will allow faster restoration of the system after a disturbance has been identified. In their research on adaptive capacity, Udo Staber and Jorg Sydow found that if a network is a closed network of few partners, it is more fragile to shocks and disturbances, such as those that exist during large-scale and catastrophic disasters. An open network allows for independent activities that can adjust over time to meet the changing demands of the event and the flexibility to react in different ways.¹²⁴

2. Socio-Technical Systems Literatures Applied to the Concept of Fragility in Emergency Management

The socio-technical infrastructure in most communities is highly fragile and susceptible to shocks and disturbances.¹²⁵ When a disaster occurs, this already fragile system is easily overwhelmed and the systems that communities have come to depend collapse, causing fear and anxiety. The effectiveness of disaster response and recovery is affected by factors such as the type and magnitude of the disaster, the number of jurisdictions involved, the capacity to respond to the disaster phases, and the structure of the systems in place before the disaster occurred.¹²⁶

¹²³ Kapucu, "Interorganizational Coordination in Dynamic Contexts," 45.

¹²⁴ Udo Staber, and Jörg Sydow, "Organizational Adaptive Capacity a Structuration Perspective," *Journal of Management Inquiry* 11, no. 4 (December 2002): 417. doi:10.1177/1056492602238848.

¹²⁵ Comfort, Ko, and Zagorecki, *Modeling Fragility in Rapidly Evolving Disaster*, 5.

¹²⁶ *Ibid.*, 4.

a. Robustness

One of the primary factors in the research regarding the robust nature of a system was in its overall structure. Emergency management has historically used a hierarchical structure similar to the military and based on the Incident Command System. This structure involves top-down decision making where all partners are within one organization.¹²⁷ Many recent studies have found, however, that this type of structure can lead to communications failures and poor information flow.¹²⁸ When disasters increase in complexity, these findings become even more relevant. Instead, many researchers, such as Waugh, and Streib, have suggested other structures that promote inclusion and utilize established community structures.¹²⁹

Two examples of this working include the emergency medical services (EMS) organizations' response to Hurricane Andrew in 1992, where they used such a horizontal structure to deliver medical supplies to clinics, and the California Department of Social Services, where they restored food service systems in South Central Los Angeles after the Los Angeles riots in 1992.¹³⁰ Many even suggest a heterarchical organization for fast moving events and disaster situations, where the organization remains more fluid and there is no hierarchy at all. Again, with regard to complex systems, this allows for the flexibility and adaptability necessary to make rapid decisions and to quickly respond and recover.¹³¹ In the *Journal of Public Administration Research and Theory*, authors Robert Agranoff and Michael McGuire state, "With no single authority, everyone is somewhat in charge, thus everyone is somewhat responsible; all network participants appear to be accountable, but none is absolutely accountable."¹³²

¹²⁷ Waugh, and Streib, "Collaboration and Leadership for Effective Emergency Management," 131.

¹²⁸ Ibid.

¹²⁹ Ibid.

¹³⁰ Koehler, Kress, and Miller, *What Disaster Response Management Can Learn*, 16.

¹³¹ Naim Kapucu, Tolga Arslan, and Fatih Demiroz, "Collaborative Emergency Management and National Emergency Management Network," *Disaster Prevention and Management: An International Journal* 19, no. 4 (August 2010): 456.

¹³² Robert Agranoff, and Michael McGuire, "Big Questions in Public Network Management Research," *Journal of Public Administration Research and Theory* 11, no. 3 (July 2001): 310.

A heterarchical structure may decrease the fragility of the emergency management organization; however, at the same time, it may lead to other difficulties. With no clear line of authority, critical information may get lost or critical resources may be missed. On the other hand, a decentralized network solves problems of authority and responsibility. Therefore, some researchers have suggested a combined approach between the hierarchical command and control structure and a collaborative network of partners. This would provide a more robust system able to manage information and provide the flexibility and adaptability necessary to work through complex events.¹³³ In an article focusing on repairing the National Emergency Management System, John Harrald states that there is a trade-off between the need for mobilizing and managing a large organization, where command and control structures are effective, and the need for organizing and coordinating between a broad spectrum of groups and communities. He argues, “Diverse organizations must achieve technical and organizational interoperability requiring common structure and process while absorbing and interacting with thousands of spontaneous volunteers and emergent organizations.”¹³⁴

b. Resourcefulness or Capacity

Increased demand typically leads to a decrease in the capacity to respond. This is frequently seen in emergencies and disasters, where a local jurisdiction are unable to effectively manage the incident independently and requests assistance from regional, state, and/or federal partners. With the interdependencies seen in emergency management systems and the networks of partners that connect them all together, a higher degree of resourcefulness is needed to ensure small system disruptions do not occur that will affect the system as a whole. This is effectively illustrated by the supply chain management operations required to provide logistical support to large-scale events. In our current age of information technology, supply chain management has acquired a complexity almost equivalent to that of an ecosystem.¹³⁵ There are the transportation systems that are

¹³³ Kapucu, Arslan, and Demiroz, “Collaborative Emergency Management,” 457.

¹³⁴ Harrald, “Agility and Discipline,” 257.

¹³⁵ Amit Surana et al., “Supply-Chain Networks: A Complex Adaptive Systems Perspective,” *International Journal of Production Research* 43, no. 20 (October 2005): 4235–65.

needed to move materials, supplies needed to support to operation, and people needed at both ends of the chain to manage the operation. This takes a high level of coordination and adaptability to ensure the support arrives as ordered. The studies in this area suggest that a failure in any one area of this network can lead to a collapse of the entire system. As seen in the Colorado Floods in 2013, if transportation routes are destroyed, the entire supply chain is disrupted.¹³⁶

c. Redundancy

In Gus Koehler's book, *What Disaster Management Can Learn from Chaos Theory*, he remarks, "Experiments by Hershey and colleagues demonstrate that a flat organization tends to produce the least disruption in information flow resulting in higher efficiencies than hierarchical organizations (Hershey, Patel, and Hahn, 1990)."¹³⁷ Many other researchers, such as Kapucu, have found similar results and have noted that network organizations have a clearly different governance structure that the hierarchies they are beginning to replace.¹³⁸ This suggests that a vertical hierarchical structure constrains information flow and innovation, perhaps increasing the fragility of the system as a whole. Instead, a decentralized horizontal structure, with varying levels and degrees of linkages allows for the adaptive flow of ideas and information, decreasing the likelihood and impact of fractures in the network.

As this paper has already illustrated, a great amount of research exists on the roles of the primary and peripheral figures in complex systems, such as ecosystems and social systems. Figure 12 illustrates three types of networks and their connections. In emergency management, historically, the most common structure has involved the emergency manager as the primary hub (keystone) with all support entities connected to this person, much like the spokes of a wheel (see Centralized Network in Figure 12). As illustrated in the literature, however, this structure leads to greater fragility overall. If the

¹³⁶ Jennifer Oldham, "Colorado Visitors Tour Estes Park as Flooded Locals Can't Flush," *Bloomberg*, September 24, 2013, <http://www.bloomberg.com/news/2013-09-24/flooded-estes-park-greets-tourists-as-locals-can-t-flush.html>

¹³⁷ Koehler, Kress, and Miller, *What Disaster Response Management Can Learn*.

¹³⁸ Kapucu, "Interorganizational Coordination in Dynamic Contexts."

emergency manager is taken out of the system, the entire network of partners would disconnect, leading to disaster disruption and chaos. A decentralized or distributed network, however, holds more promise as no one hub will cause failure of the network.

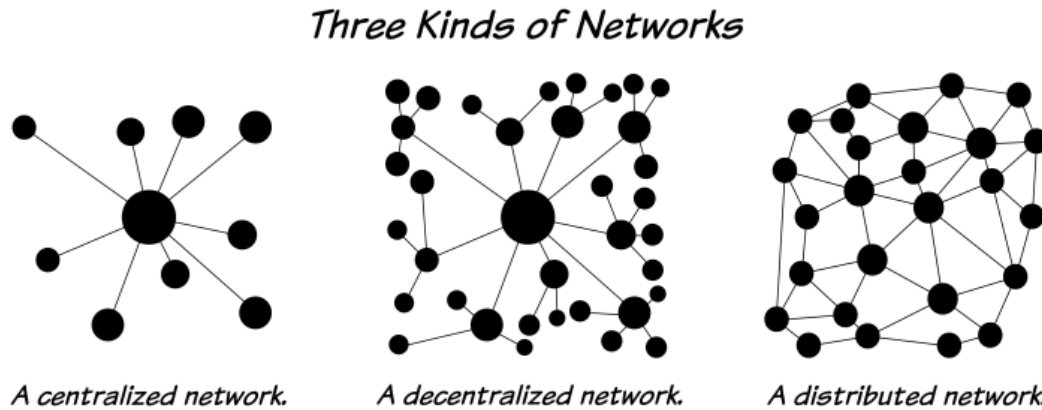


Figure 12. Centralized, decentralized and distributed networks

Many argue that a decentralized structure is much less fragile as the system consists of a variety of hubs that intersect with the central figure. This is illustrated in the changing nature of terrorist organizations since the attacks on September 11, 2001. In the past, terrorist networks had one central figure, such as Osama Bin Laden. But many terrorist organizations quickly realized the fragility of such a structure when the Federal Bureau of Investigation (FBI) and Central Intelligence Agency (CIA) started to remove the most central figures from the network, leaving the rest in shambles. At present, most terrorist organizations work in cells, where groups of people cluster together with weak links between each, allowing them to survive if one individual or group is removed.¹³⁹

Finally, some researchers suggest a model more similar to a distributed network as seen in Figure 12. This model would allow for greater overall communication and coordination amongst partners without completely relying on a central figure, such as an emergency manager. Some hubs within the network would be more connected than

¹³⁹ Choi, "When Practice Matters More Than Government Plans," 672.

others, but they would all have weak links tying them all together.¹⁴⁰ This is similar to the studies on crowd disasters that illustrated that no one person or group will have all of the information needed to prevent system failures. Instead all parts of the system should be considered.¹⁴¹

In interdependent networks, however, researchers have found that not only will the one network fail, but it will cause systemic failures throughout all of the networks connected within the system.¹⁴² From an emergency management perspective, this occurrence was clearly illustrated during the 2003 blackout in the northeastern United States as well as Hurricane Katrina in 2006 where one failure cascaded into another and led to systemic failures overall.¹⁴³

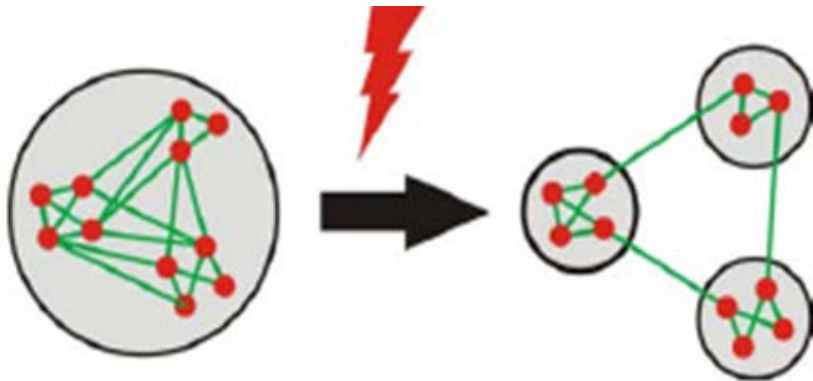


Figure 13. Example of Compartmentalization within Systems

It is further argued that it is our highly interconnected systems and networked risks that have created these types of failures. For example, studies have shown that major disasters do not always have large causes. Instead, researchers have found that small events can often lead to larger consequences when they link with other small events

¹⁴⁰ “The Law of Rule: Centralized, Decentralized and Distributed Systems,” Canada Foundation for Nepal, accessed December 27, 2014, <http://cfn.ca/2009/04/the-law-of-rule-centralized-decentralized-and-distributed-systems/>

¹⁴¹ Challenger, and Clegg, “Crowd Disasters,” 344.

¹⁴² Alessandro Vespignani, “Complex Networks: The Fragility of Interdependency,” *Nature Magazine* 464, no. 15 (April 2010), 985.

¹⁴³ *Ibid.*, 984.

within the system. As our technology becomes increasingly interconnected, Rudolph and Repenning suggest that this will increase the likelihood of chain reactions.¹⁴⁴ Therefore, they suggest that for highly interdependent systems, that we limit the degree of connectedness and the size of each network.¹⁴⁵

Figure 13 clearly illustrates how a large network could be deconstructed into several smaller networks, where they remain connected through weaker links (a network of networks). This allows the system to function effectively without spreading network problems to the whole. Additionally, as was previously mentioned, by adding a degree of diversity amongst the various networks, the overall system is better able to manage and share information as well as solve complex problems.¹⁴⁶

d. Rapidity

Because of the intricate network of partners within emergency management, the capacity to move information through multiple systems in an effective and efficient manner is essential. Emergency management cannot exist as a closed network due to this number of partners in governmental, private, and non-governmental organizations. When looking at open networks, the research indicates that stability decreases; however, these systems are less fragile to shocks and disturbances. Furthermore, research indicates that with the broader perspective of a number of partners, we will see faster restoration of disturbances and failures. Therefore, from an emergency management perspective, open systems will allow for better adaptive capacity, a broader perspective, and a better opportunity to not only anticipate and find failures early but to also find solutions. Figure 14 outlines the key measurements of fragility in socio-technical systems.

¹⁴⁴ Jenny W. Rudolph, and Nelson P. Repenning, "Disaster Dynamics: Understanding the Role of Quantity in Organizational Collapse," *Administrative Science Quarterly* 47, no. 1 (March 2002): 1, doi:10.2307/3094889.

¹⁴⁵ Helbing, *Systemic Risks in Society and Economics*.

¹⁴⁶ *Ibid.*, 16.

Measuring Fragility in Socio-Technical Systems

- System fragility—Measured by its robustness, resourcefulness, redundancy and rapidity
- Diversity—Variety of partners within the networks will add value and decrease fragility
- Authority—A combination of vertical (hierarchical) and horizontal collaborative approaches create flexibility and adaptability and provide the most effective approach to decrease fragility in rapidly changing events
- Central actors—Identifying organizations that are most and least prominent in a network will allow emergency managers to develop strategies to build on strengths while also for increasing the capacity of more peripheral agencies
- Supply versus demand—The capacity to respond is negatively affected by the increase in demand for resources
- System thresholds—Determining how many people can be added or subtracted from a network before a failure occurs will allow for better planning efforts for future operations.
- Open systems—Creation of open systems leads to diverse information flow and less likelihood of failure due to shocks or disturbances

Figure 14. Fragility Measurements in Socio-Technical Systems

G. COMPLEX ADAPTIVE SYSTEMS

The study of complex adaptive systems has been the focus of many research projects in an effort to find common characteristics between complex systems, such as ecosystems, social systems, and technological systems, in an effort to better understand how complexity occurs.¹⁴⁷ Complex adaptive systems are systems with a large number of components that interact and adapt and learn. This leads to change over time, hopefully improving performance and decreasing fragility of the system as a whole.

1. Relevant Bodies of Literature on Complex Adaptive Systems

A group of scientists at the Royal Swedish Academy of Sciences use the concept of resilience as their basis for better understanding how social and ecological systems can

¹⁴⁷ Surana et al., "Supply-Chain Networks," 4235–65.

sustain in our new complex environment.¹⁴⁸ They explain that resilience is related to the following three characteristics: 1) how much of a shock the system can absorb while remaining intact, 2) the degree to which the system is self-organizing, and 3) the degree for which the system is able to build capacity for learning and adaptation.¹⁴⁹ Resilient systems are better able to absorb shocks and are better able to reorganize and learn during dramatic events. Each of these factors is illustrated in complex adaptive systems.

The majority of research regarding complex adaptive systems has been made in the social sciences field. For example, Russell Dynes and Enrico Quarantelli identified the idea of emergence in community structures following disasters.¹⁵⁰ They recognized that in events such as catastrophic disasters, communities will self-organize and create new structures in order to best manage an event. And much like in social and technical systems, they were able to demonstrate that failures routinely occurred in closed system models where centralized decision making was made in a command and control network. In contrast, they found that problem-solving models in open systems were better able to cope with change and the need for increased coordination and cooperation from a large number of partners,¹⁵¹ much like the models suggested in the section on socio-technical systems.

All complex adaptive systems that have been studied exhibit the same phenomenon regarding one aspect of fragility, previously described as a tipping point. Each system has a point where a simple intervention or disturbance causes a lasting effect—either positive or negative. For example, vaccines cause lasting change within the immune system. However, there is currently no theory that is able to pinpoint how or where to look specifically for these tipping points. Additionally, all complex adaptive systems have been shown to evolve in an open-ended manner, where a simple system begins to exhibit increasing diversity of information exchange and interaction. Finally,

¹⁴⁸ Folke et al., “Resilience and Sustainable Development,” 438.

¹⁴⁹ Ibid.

¹⁵⁰ Harrauld, “Agility and Discipline,” 264.

¹⁵¹ Ibid.

the process of this change in systems complexity leads to a greater number of available resources and a diversity in the system that did not exist previously.¹⁵²

2. Complex Adaptive Systems Literatures Applied to the Concept of Fragility in Emergency Management

Organizations with limited adaptive capacity tend to search for known solutions to problems. They use those capabilities and abilities they already possess to determine the best possible outcome. During a complex emergency or disaster, this may lead to a rigid structure, one unable to bend and adapt as needed to effectively manage the event. On the other hand, those organizations with adaptive capacity avoid structures that are too rigid, knowing that circumstances rarely, if ever, remain the same in each disaster.¹⁵³ In a study by Nelson Repenning and Jenny Rudolph from Cornell University, they state, “People must step back from the situation at hand, revisit their core assumptions, reframe the situation, recombine existing procedures and routines into alternative responses (e.g., improvisation), and engage in some type of higher-order evaluation.”¹⁵⁴ Louise Comfort, Director for the Center for Disaster Management at the University of Pittsburgh, agrees, stating that the ability for organizations to build adaptive capacity during emergencies and disasters is a “key predictor of success.”¹⁵⁵ The ability to grow and adapt has been seen in the emergency management field in recent years, specifically since the terrorist attacks of September 11, 2001. Emergency management organizations were predominantly structured in a quasi-incident command structure, but over the years many found that this could not meet the increasing need for collaboration and support. From there, the concept of emergency support functions emerged, linking several non-traditional partners to the incident response and recovery.¹⁵⁶

¹⁵² John Holland, “Studying Complex Adaptive Systems,” *Journal of Systems Science and Complexity* 19 (2006): 7.

¹⁵³ Staber, and Sydow, “Organizational Adaptive Capacity a Structuration Perspective,” 410.

¹⁵⁴ Rudolph, and Repenning, “Disaster Dynamics,” 25.

¹⁵⁵ Harrauld, “Agility and Discipline,” 265.

¹⁵⁶ Kapucu, “Interorganizational Coordination in Dynamic Context,” 34

Another key characteristic displayed by complex systems is the emergence of highly structured collective behavior over time from the interaction of simple groups without any centralized control. They exist in a state of perceived equilibrium with a combination of regularity and randomness.¹⁵⁷ Complexity is driven by the need for robustness to uncertainty, leading to a decrease in fragility. This leads to self-organization, which is essential in a flexible, adaptable environment such as emergency management.

Since its inception after the events of 9/11, the Department of Homeland Security has focused its efforts in developing a common national approach to incident management. This has been done through a series of plans and procedures, such as the National Response Framework, the National Incident Management System, and national preparedness goals. This focus on standardized processes and step-by-step procedures may have actually had an adverse effect on our ability to manage catastrophic events, where adaptability and flexibility are essential. Additionally, national policies based upon one standard set of actions does not address the diversities of the people, cultures, geography, and technology throughout the United States, further increasing the fragility of communities that do not fit into the standard model.¹⁵⁸

It is a challenging task to effectively collaborate and integrate multiple partners and players in a large-scale emergency response that is both dynamic and chaotic. Moreover, this becomes more challenging as the number of partners grows and the scale of the incident intensifies.¹⁵⁹ Therefore, it is necessary to build systems and networks in a way that makes them highly adaptable to change and disorder, and thus, making them less fragile.

In the emergency management field, networks may very well have to change over time with the changing conditions of the community or the disaster. With each

¹⁵⁷ Surana et al., "Supply-Chain Networks,"

¹⁵⁸ Harrauld, "Agility and Discipline," 258.

¹⁵⁹ Liaquat Hossain, and Shahadat Uddin, "Design Patterns: Coordination in Complex and Dynamic Environments," *Disaster Prevention and Management: An International Journal* 21, no. 3 (June 2012): 337, doi:10.1108/09653561211234516

experience, the people and networks involved will learn from the event and from one another, leading to changes in the way the interactions work in the future. This is often called a “feedback loop” where the information learned returns to the network in the form of new knowledge and practices.¹⁶⁰ The result is a dynamic network of partners. Studies focusing on complex adaptive systems illustrate these changing interactions. Because emergency management is a nonlinear dynamic field, our processes and procedures must account for adaptation and the ability to respond to changing demands and conditions, rather than relying on strict adherence to prior rules and restrictions (see Figure 15).¹⁶¹

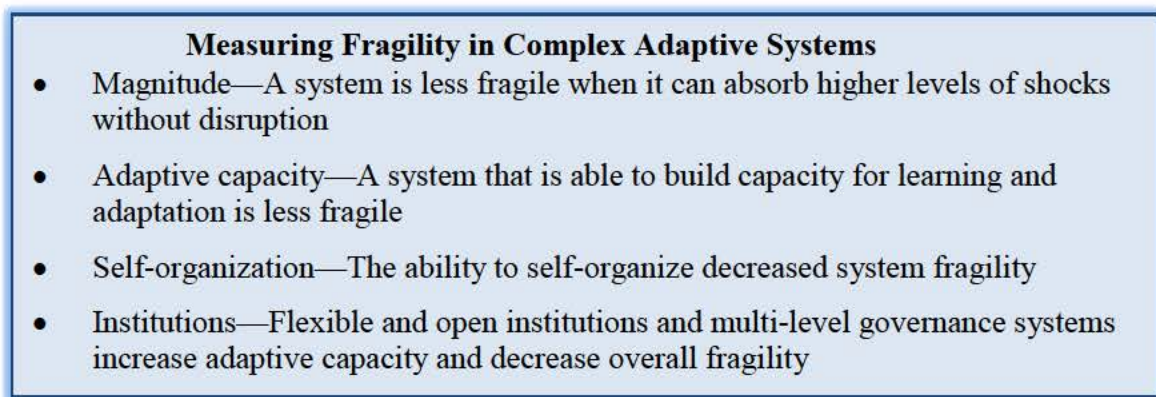


Figure 15. Fragility Measurements in Complex Adaptive Systems

H. THEORETICAL FRAMEWORK

In this thesis, the theoretical framework illustrates how the characteristics of fragility in multiple complex systems can be utilized as characteristics in the emergency management field to assess community fragility. The inference is that the variables in complex systems can, and should, be used to determine fragile systems in emergency management. The key question this process is meant to answer is whether the characteristics of fragility demonstrated in complex systems can be transferred to determine community fragility before, during and after disasters.

¹⁶⁰ Choi, “When Practice Matters More Than Government Plans,” 658.

¹⁶¹ Currao, “A New Role for Emergency Management,” 15.

The first step of this process was to create a fragility matrix, illustrating each of the key factors outlined in the conceptual development section of this chapter (see Table 1). The matrix is broken into sections based upon three factors. The first is the type of system studied in the literature review. Second, the matrix outlines the key concepts of fragility for that specific system. Finally, the right side of the matrix defines each of the key concepts more clearly. The fragility matrix on the following page summarizes the work of the literature review.

Table 1. Fragility Matrix from Relevant Literature

Fragility in Ecological Systems and Food Web Networks	
Removal of Species	Removal of primary species (keystone) causes instability Removal of weaker species can also cause a trickle-down effect
Fragile Ecosystems	Combination of weak and strong species creates less fragility
Diversity	Interactions and diversity strengthen the system as a whole
Fragility in Social Systems	
Empowering Citizens	Contributes to confidence and feelings of worth, decreasing fragility
Community Ties	Connections with friends and family are the primary ways in which people get the resources they need to survive
Larger Networks	Larger networks are more supportive and better able to find needed resources, less fragile to shocks and disturbances
Social Cohesion	A lack of social cohesion leads to a decrease in trust and increase in community fragility
Social Capital	High degree of social capital contributes significantly to social, political and economic performance Active participation in community activities Higher cooperation with formal emergency response systems
Trust	High social capital contributes to a high level of trust which leads to better cooperation and coordination
Resilient Systems	Better able to absorb shocks and learn during dramatic events
Basic Human Needs	Ability to meet basic needs decreases stress and increases the ability to cope, decreasing the fragility of communities and systems
Socio-Technical Systems	
Diversity	Variety of partners within the networks will add value and decrease fragility
Authority	A combination of vertical (hierarchical) and horizontal collaborative approaches create flexibility and adaptability and provide the most effective approach to decrease fragility in rapidly changing events
Central Actors	Identifying organizations that are most and least prominent in a network will allow individuals to build strategies to maintain strengths and increase the capacity of peripheral agencies
Supply vs. Demand	Capacity to respond is negatively affected by the increase in demand of resources
System Thresholds	Determining how many people can be added or removed from a network before a failure occurs will allow for better planning efforts
Open Systems	Creation of open systems leads to diverse information flow and less likelihood of failure due to shocks or disturbances
Complex Adaptive Systems	
Magnitude	A system is less fragile when it can absorb higher levels of shocks without disruption
Adaptive Capacity	A system is less fragile when it is able to build capacity for learning and adaptation
Self-Organization	A system is less fragile when it has the ability to self-organize
Institutions	Flexible and open institutions and multi-level governance systems increase adaptive capacity and decrease overall fragility

The second step in this process was to create a theoretical framework for community fragility, found on the following page (see Figure 16). The left side of the framework takes the key fragility characteristics found in the literature review on complex systems from the fragility matrix (Table 1). On the right side, those same characteristics are listed from an emergency management perspective. These characteristics are further divided into three specific focus areas: connectedness, stability, and sustainability.

The first area, connectedness, involves the emergency management and community structures that connect people together. This includes the development of social capital, the difference between strong and weak organizational connections, the dangers for isolated communities, and the chosen structure for the emergency management system in dealing with disasters.

Stability involves many of the fragility factors that may create an unstable environment. This area is most affected by strong and weak leadership within the community, the flexibility of planning models, and the degree of compartmentalization in emergency management systems. Weak leadership could lead to a lack of trust, further affecting social capital. On the other hand, strong leadership may lead to better planning efforts with more flexibility and adaptability. Moreover, the compartmentalization of the emergency management system could also lead to greater stabilization and less of a chance for small disturbances to cause problems.

The final factor in the framework includes those items from the fragility matrix that are directly related to sustainability of the community. This involves building resiliency, resource management, lifelines, and the identification of cascading events. By providing for lifeline restoration and supply chain management, communities may have the support they need to better recover, also making them more resilient. Figure 16 provides a visual representation of the theoretical framework.

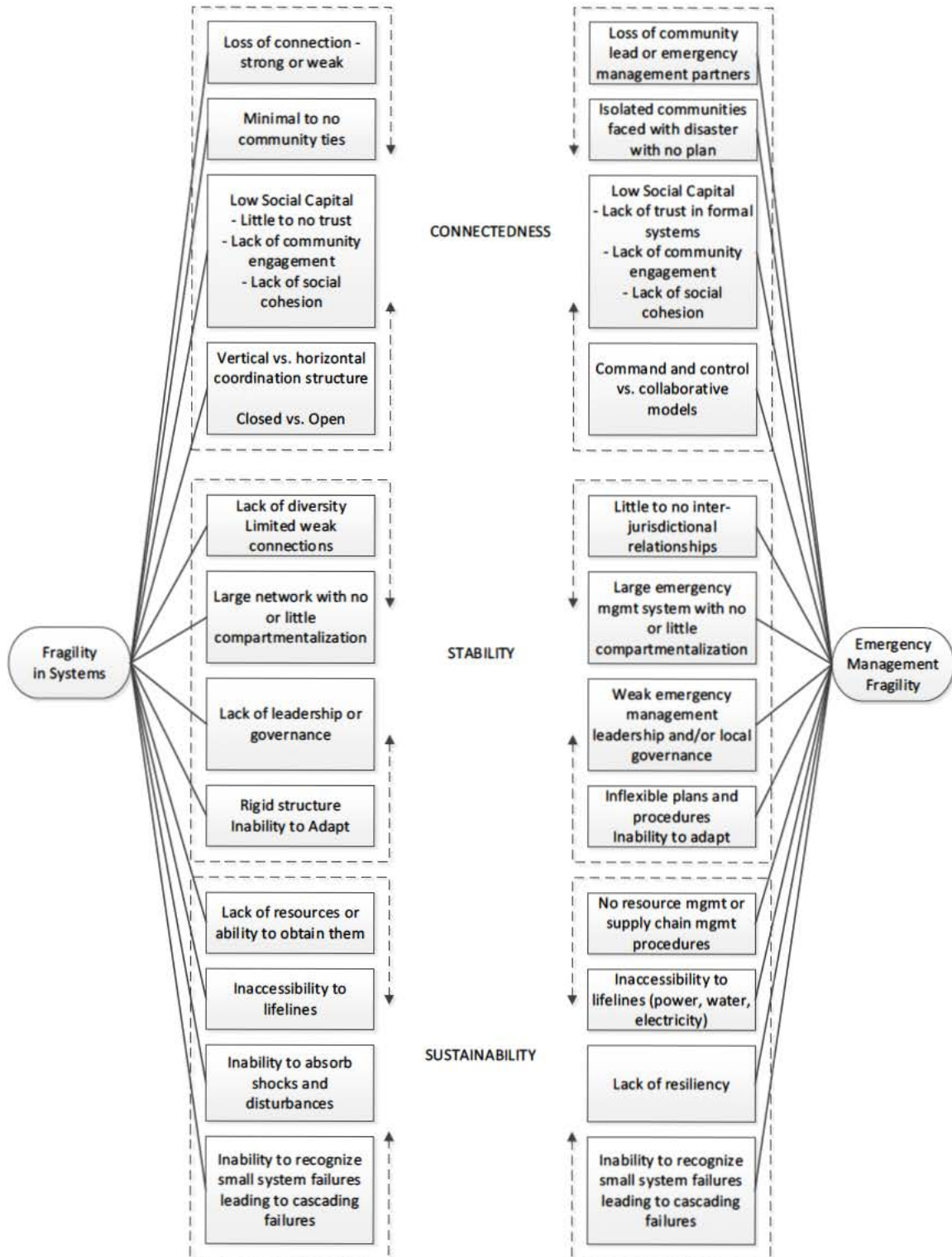


Figure 16. Theoretical Framework for Community Fragility in Emergency Management

I. LITERATURE REVIEW AND CONCEPTUAL DEVELOPMENT CONCLUSION

The area of focus for this research involves community structures, emergency management, and the concept of fragility between these two areas. Since there is very little research currently on the idea of community fragility in emergency management, several other fields were explored in the literature review, including ecosystems, social systems, socio-technical systems and complex adaptive systems. These were systematically chosen due to their complex nature and their relevance to the emergency management field. Once the data was collected in the literature review, the conceptual development section identified the connections, or relevancy, between the concepts of fragility in these complex systems and their possible use in developing a theory on community fragility in emergency management. Common themes and key points were extrapolated from the literature and conceptual development to create a fragility matrix, illustrating each system and its key characteristics. Finally, assumptions have been made to begin the development of a causal prediction model, which is further evaluated and refined through a multi-method approach in the research design.

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III. METHOD AND RESEARCH DESIGN

“Anticipation is about perceiving the world, relating to it, moving around in it, making sense of it, thinking about what to expect from it, and what possibilities exist that one can gain from.”

–Mark Nuttall

A. INTRODUCTION

This research seeks to answer the question of how the fragility of a community can be measured and what the implications would be for the field of emergency management. The second research question explores whether this model of community fragility can be a useful tool in emergency management. To answer these questions, this research uses a multi-method approach. First, the literature review examines data from primary and secondary sources, including a variety of articles, reports, books, and research studies regarding the concept of fragility to determine if community fragility has been previously measured and to what extent. From there, information gleaned from the conceptual development section of the literature review is used to create a theoretical framework, connecting the measurements of fragility in systems to the areas of proposed fragility in emergency management. Non-probability purposive event sampling is completed using multiple case study analysis to determine if the theoretical framework is sound. Finally, the framework is refined and a causal prediction model is created for community fragility in emergency management. This multi-method approach effectively addresses both of the research questions and provides a path forward for future research on community fragility. Each of these methods is addressed in greater detail within the following sections of this chapter.

B. THEORETICAL FRAMEWORK

A theoretical framework provides the basis for qualitatively analyzing the data available on fragility from the literature review and the conceptual development. As stated previously, little research has been conducted on fragility in emergency management; however, several studies have been conducted on fragility in various

systems. By utilizing information found in the literature on ecosystems, social systems, socio-technical systems, and complex adaptive systems, assumptions can be made about the factors that would influence fragility in the emergency management field.

The theoretical framework can strengthen this study in multiple ways. First, the framework connects the research to existing knowledge, providing a strong basis for theoretical assumptions. Second, by extrapolating pertinent studies and analytic models that are relevant to the research question, it is easier to critically evaluate such assumptions. Finally, a theoretical framework helps to explain the challenges and opportunities associated with a phenomenon in order to use that knowledge and understanding to create positive future action.¹⁶²

C. MULTIPLE CASE STUDY ANALYSIS

The study design for this thesis continues with a qualitative multiple case study approach to examine the theoretical framework as a measurement of community fragility in emergency management. According to Robert Yin, “The case study method is best applied when research addresses descriptive or explanatory questions and aims to produce a first-hand understanding of people and events.”¹⁶³ For example, the case study method has been used extensively in psychology. Some of the best known case studies were ones carried out by Sigmund Freud to examine the home lives of individuals to better understand possible causes of their mental illness.¹⁶⁴ The primary benefit of this type of analysis is that it allows the researcher the opportunity to explore a situation in context using a variety of sources. In the case of disaster research, case studies are often used to determine lessons learned and to strengthen systems before another disaster occurs.

¹⁶² Richard A. Swanson, and Thomas J. Chermack, *Theory Building in Applied Disciplines*, 1st ed. (San Francisco: Berrett-Koehler Publishers, 2013).

¹⁶³ Robert K. Yin, *Applications of Case Study Research*, 3rd ed. (Thousand Oaks, CA: Sage Publications Inc., 2011), 3.

¹⁶⁴ Saul McLeod, “Case Study Method,” Simply Psychology, 2008, <http://www.simplypsychology.org/case-study.html>

This paper uses a multiple case study approach consisting of three diverse large-scale disasters. Cases are also examined holistically, allowing for the exploration of similarities and differences within and between cases. The three case studies chosen for analysis were selected based upon five criteria. Each disaster: 1) qualifies as a mega-disaster, where the destruction overwhelmed the local community and the state, 2) occurred in the last decade to ensure relevancy, 3) transpired due to natural causes, 4) occurred in the United States, and 5) is located in a different area of the nation. The goal is to examine each of the key variables in the theoretical framework through the lens of each disaster and to determine if the fragility model can be replicated across multiple cases.

D. SAMPLING

This research involves non-probability purposive event sampling, focusing on specific disaster events since the creation of the new Department of Homeland Security and the establishment of the National Incident Management System to ensure relevancy. This provides a means to illustrate the measures of community fragility in an emergency management setting and to determine if the theoretical framework is valid.

A sample is defined as a smaller representative collection of information from an event used to determine truths about that event, and there are two types of samples: probability and non-probability. The primary difference between the two is that non-probability sampling does not involve random selection and probability sampling does.¹⁶⁵ For example, in probability sampling, all disasters would have the same opportunity to be included in the sample, and the mathematical probability of the selection of any one of them could be calculated. When the probability of selection cannot be determined, non-probability event sampling is used. Therefore, for purposes of this research, non-probability event sampling is more meaningful.

This method is further divided into two types of non-probability event sampling: accidental or purposive. An example of accidental event sampling would be a newscaster

¹⁶⁵ "Nonprobability Sampling," Research Methods Knowledge Base, Web Center for Social Research Methods, accessed January 15, 2015, <http://www.socialresearchmethods.net/kb/sampnon.php>

out on Time Square asking random people questions to get a quick idea about public opinion. In contrast, an example of purposive sampling would be an individual standing in front of a veterinary office asking specific market research questions about animals.¹⁶⁶ For the purposes of this research, purposive event sampling is used to study community fragility in emergency management.

Event samples are utilized from three diverse areas of the United States. In order to evaluate community fragility, successes and failures will be explored based upon the criteria outlined in the theoretical framework. Large-scale disasters that reached a point of fragility, or tipping point, are researched as well as those that did not in order to compare and contrast the events and to determine if the metric for community fragility is sound.

E. CAUSAL PREDICTION MODELING

The final phase of the methodology involves causal prediction modeling. A causal prediction model is defined as, “a network of variables with causal connections among them, drawn from multiple-case analysis.”¹⁶⁷ In essence, the process of causal prediction modeling involves focusing on knowing what will happen to one variable when you change another (if X, then Y).¹⁶⁸ For example, what would happen to public opinion regarding a disaster if television coverage focused on a political scandal in the same jurisdiction? Would the trust in the disaster recovery go down, ultimately affecting the community?

The multi-case analysis provides the information required to analyze the theoretical framework and make necessary adjustments. Additionally, this analytic process provides the foundation for the development of a meaningful explanatory model.

¹⁶⁶ Ibid.

¹⁶⁷ Matthew B. Miles, A. Michael Huberman, and Johnny Saldaña, *Qualitative Data Analysis: A Methods Sourcebook*, 3rd ed. (Thousand Oaks, CA: Sage Publications, Inc., 2013).

¹⁶⁸ Gary King, “‘Truth’ Is Stranger than Prediction, More Questionable than Causal Inference,” *American Journal of Political Science* 35, no. 4 (November 1991): 1050.

F. CONCLUSION

Each stage of this research builds upon the one before it to create a complete picture. Past research is used to develop a concept regarding fragility in systems, and a framework is developed from the literature. By using multi-case analysis, this framework is refined to include factors affecting community fragility within the emergency management field. The finished product of this analysis is a causal predictive model demonstrating the use of the fragility concepts in the emergency management field.

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IV. MULTIPLE CASE STUDY ANALYSIS

“A pessimist sees the difficulty in every opportunity.
An optimist sees the opportunity in every difficulty.”

–Winston Churchill

A. INTRODUCTION

The case studies presented in this section include the Joplin tornado from 2011, the San Diego County firestorms from 2007, and Hurricane Katrina in 2005, specifically focusing on New Orleans, Louisiana. First, each case study is presented by providing a brief history of the event and areas identified as successes and failures. Next, an analysis is made between the theoretical framework and the relevant facts from the disaster to determine how each characteristic can be used to measure community fragility. Finally, each sample provides a summation of the data and analysis, along with a visual representation of the results, leading to the development of the causal prediction model.

B. CASE STUDY 1: JOPLIN MISSOURI TORNADO, 2011

“As lightning pops and thunder booms, you can see the locals flinch. It’s likely too close for comfort after they lost 89 neighbors to a half-mile wide twister.”

–Eric Marrapodi, CNN Producer in Joplin Missouri

1. Synopsis of the Event

On May 22, 2011, one of the most powerful tornadoes in American history touched down in Joplin, Missouri, located near the Kansas, Missouri, Arkansas, and Oklahoma borders. Joplin Missouri has a population of over 50,000 people and 4,200 businesses, according to 2010 census records.¹⁶⁹ The city is also the commercial, medical, transportation, and educational center for the region, increasing the daytime population to over 250,000 people.¹⁷⁰

¹⁶⁹ U.S. Census Bureau, “State and County Quickfacts” [Joplin, Missouri], accessed January 12, 2015, <http://quickfacts.census.gov/qfd/states/29/2937592.html>

¹⁷⁰ Ibid.

At 5:41pm on May 22, 2011, the National Weather Service tracked a supercell thunderstorm from extreme southeast Kansas into far southwest Missouri; it produced the powerful tornado that devastated the area.¹⁷¹ A tornado of this strength had not touched down in Missouri since 1957. According to the National Weather Service,

The tornado was rated EF-5 on the Enhanced-Fujita Scale, with its maximum winds estimated at more than 200 mph. The path of the entire tornado was 22.1 miles long and was up to 1 mile in width. The EF-4/EF-5 damage path was roughly 6 miles long...and generally ½ to ¾ of a mile wide along the path.¹⁷²

Because the path of the tornado was almost entirely in the city of Joplin, catastrophic damage was reported to multiple areas of the city (see Figure 17).¹⁷³ For example, according to a National Center for Disaster Preparedness report, over 30 percent of the city and over 8,000 structures were damaged, and another 3,500 structures were completely destroyed. These damages displaced one third of the city's entire population, approximately 17,000 people.¹⁷⁴

In addition, the tornado destroyed six of the public school system's school buildings and damaged another four. The tornado destroyed much of the medical infrastructure within Joplin as well. This included medical offices, six nursing homes, two dialysis centers, eight behavioral health facilities, four home health agencies, a hospice agency, and a detox center.¹⁷⁵ Most notably, however, was the complete destruction of one of the two major hospitals in the city, Mercy St. John's Regional Medical Center, which had a capacity of 367 beds.¹⁷⁶

¹⁷¹ National Weather Service Weather Forecast Office, "Springfield, MO, Joplin Event Summary," May 22, 2011, http://www.crh.noaa.gov/sgf/?n=event_2011may22_summary

¹⁷² Ibid.

¹⁷³ David M. Abramson, and Derrin Culp, *At the Crossroads of Long-Term Recovery: Joplin, Missouri Six Months after the May 22, 2011 Tornado* (National Center for Disaster Preparedness, Earth Institute, Columbia University, 2013), <http://hdl.handle.net/10022/AC:P:217606>

¹⁷⁴ Ibid.

¹⁷⁵ Ibid.

¹⁷⁶ Ibid., 173.

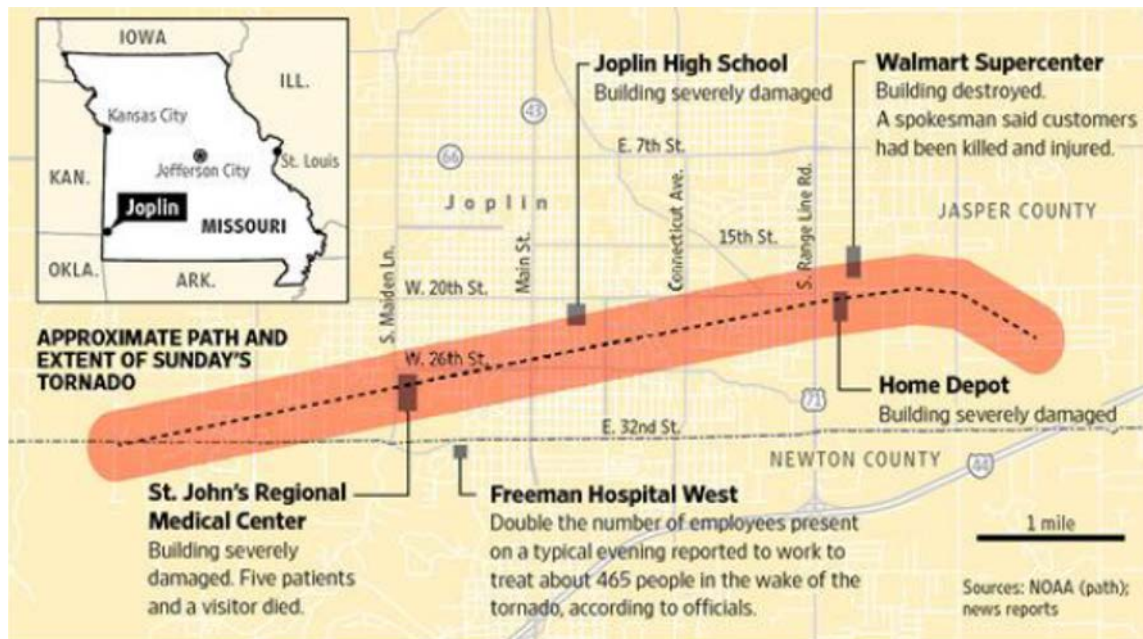


Figure 17. Joplin Tornado Path¹⁷⁷

The principal of Joplin High School remarked to a reporter,

You see pictures of World War II, the devastation and all that with the bombing. That's really what it looked like...I couldn't even make out the side of the building. It was total devastation in my view. I just couldn't believe what I saw.¹⁷⁸

After the tornado, several days of severe weather followed, making it difficult to truly grasp the devastation throughout Joplin. However, as soon as it was safe to do so, key officials began damage assessments. The city of Joplin's Emergency Management Team, which includes government officials, fire officials, and police agencies, began working on the recovery plan for each day's work ahead. Their first priorities involved search and rescue operations and emergency debris removal to ensure rescuers could get into the areas where the need was the greatest. State officials were also available very quickly to assist with damage assessments and to determine unmet needs. They began the process of a state declaration immediately and by the morning following the tornado,

¹⁷⁷ "Nature in the News: Joplin Tornado Path Map," May 25, 2011, <https://blackjackoak.wordpress.com/2011/05/25/joplin-tornado-path-map/>

¹⁷⁸ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*.

Federal Emergency Management Agency (FEMA) crews began arriving in Joplin.¹⁷⁹ Ultimately, this disaster caused 161 fatalities, and over 1,000 more people were injured. The Joplin tornado is the deadliest single tornado since modern record keeping began in 1950 and is ranked seventh among the deadliest tornadoes in U.S. history.

2. Joplin Community—Connectedness

The analysis of connectedness as a degree of community fragility has four components: isolation of the community, lack or surplus of social capital, the effect of a loss of a community leader, and the emergency management organizational model utilized during and after response.

Joplin, Missouri is not a very diverse community in terms of ethnicity. The largest ethnic group in Joplin is Caucasian at 93 percent of the population. Smaller ethnic groups, such as Asian, Native American, and African American individuals, comprise the remainder of the population. The median income for a family is \$35,566 and the poverty rate is 18.3 percent, both of which are below the state average.¹⁸⁰

In the available literature, however, there is nothing to suggest that Joplin is an isolated community. To the contrary, Joplin seems to be well connected from a transportation, manufacturing, medical, and economic base. In one study of the disaster, the authors looked at the nature of the damage, the social and political environment, and the community's pre-tornado experiences and found that all three "created a favorable foundation for recovery."¹⁸¹ Additionally, the researchers found no evidence of conflict in the city's civic or political culture and trust in elected officials was also found to be quite high, even in the face of an upcoming election in November that year. They found that "while disputed political terrain undoubtedly exists in Joplin as it does everywhere else, it appears to be a less significant factor in recovery in Joplin than in other communities."¹⁸²

¹⁷⁹ Jessi Preussner, *Examination of FEMA and the Relationship with a Community after a Disaster* (Manhattan, KA: Kansas State University, 2012), <http://krex.k-state.edu/dspace/handle/2097/13694>, 31.

¹⁸⁰ Ibid., 21.

¹⁸¹ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 8.

¹⁸² Ibid., 11.

Most notably, however, was the degree of social capital and the connections between government and non-government organizations. Joplin is an area where faith-based and other community groups appear to be integral partners in the day-to-day delivery of city services and are often utilized for response and recovery operations. Before the disaster, local churches were significant partners of both the school system as well as local government. After the disaster, this degree of connectedness within the community allowed for a better overall recovery. According to Jay St. Clair, a local church outreach minister, “This faith component, this undercurrent that was there before [the tornado], that was building. The tornado has stirred that up...it didn’t create it, it just stirred up what was already there and magnified it.”¹⁸³

From an economic perspective, 20 percent of the population is employed in the manufacturing industry, 15 percent in retail and another 10 percent in construction.¹⁸⁴ According to a 2011 report on Joplin’s long-term recovery, “Joplin is an environment in which the business community, as embodied in the Joplin Area Chamber of Commerce, is a full partner with local government in local and regional economic development.”¹⁸⁵ One such economic development partnership is known as the Joplin Regional Partnership of Southwest Missouri and Southeast Kansas, which involves six counties. This group discusses issues of unemployment, job training, and recruitment to the area.¹⁸⁶ After the tornado, many people of Joplin who were interviewed believed that the disaster had not diminished the economic vitality of the city. Researchers state,

Without exception, our informants had immense faith in the power and durability of Joplin. The tornado had not, in their view, fundamentally diminished or impaired the retail economic engine that makes Joplin the regional hub for southwest Missouri and the surrounding counties in Kansas, Oklahoma and Arkansas.¹⁸⁷

¹⁸³ Ibid., 12.

¹⁸⁴ Preussner, *Examination of FEMA*, 21.

¹⁸⁵ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 12.

¹⁸⁶ Preussner, *Examination of FEMA*, 21.

¹⁸⁷ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 13.

Joplin Missouri did not have a loss of a community or political leader during this disaster, therefore it is not possible to evaluate this component. Another area that is difficult to analyze involves the emergency management organization. According to the *Joplin/Jasper County Emergency Operations Center Operations Manual*, the City of Joplin uses an Incident Command System organization for its emergency management response operations.¹⁸⁸ This organization involves a hierarchy from an emergency operations center (EOC) manager (similar to an incident commander) down to section chiefs and units. By examining this manual, it seems that Joplin has a closed system, with specific roles and responsibilities for the City of Joplin staff. As the research above indicates, it is apparent that many other organizations are involved in emergency response and recovery.

According to Michelle Ducre, the Southwest Missouri Director of Development for the Community Foundation of the Ozarks, “If you want a seat at the table you pretty much have it. There’s not been anybody that I’ve seen in the seven years I’ve been here denied access to the process if they wanted to be a part of it.”¹⁸⁹ Therefore, while it would seem on paper that Joplin uses a command and control hierarchy for emergency management, all other evidence points to more of a collaborative model. The Joplin emergency management coordinator stated in the publication, *Joplin Pays It Forward*,

In the past we have trained for tornados, but never one that would strike us so hard that it would overwhelm our local resources immediately, thus requiring us to reach out to a large number of people and organizations for help and support, attempt to coordinate their efforts and all the while maintain ongoing, viable City operations.¹⁹⁰

Mayor Mike Woolston reiterated the role of community spirit and social capital within Joplin after the disaster. In a publication by community leaders, he describes that within the first 48 hours, community members were already out clearing debris from

¹⁸⁸ *Joplin/Jasper County Emergency Operations Center Operations Manual*, last modified April 2009, Southwest Missouri Emergency Support Organization, smeso.org/downloads/EOCOperationsManualUpdated040709.doc

¹⁸⁹ Ibid.

¹⁹⁰ Jane Cage, and Rich Serino, *Joplin Pays It Forward: Community Leaders Share Our Recovery Lessons* (Joplin, MO: Jane Cage, 2013), <http://joplincc.com/Joplin%20Pays%20It%20Forward%20-%20Community%20Leaders%20Share%20Our%20Recovery%20Lessons.pdf>, 21.

properties and many began rebuilding efforts within the first week. He commented on the reasons why the city was able to recover so quickly, attributing it to the initial and ongoing response by the local citizens, working together with over 175,000 volunteers, who allowed them to move forward. In addition, Woolston states, “I believe it was the initial actions and tone set by formal and informal leaders in the community that got us started in the right direction but it was the volunteers and our citizen response that keeps us moving forward.”¹⁹¹

3. Joplin Community—Stability

Stability plays a role in community fragility through community relationships, emergency management leadership, emergency management structure, and the ability to be flexible and adapt to emerging events. As mentioned in the previous section, by all accounts Joplin had strong interjurisdictional relationships before the disaster that assisted in both response and recovery operations. This included governmental partners as well as non-profits, volunteer organizations, and the private sector.

Within the first few months of the tornado touching down, four key actions occurred to ensure a positive recovery. First, the city government coordinated with the U.S. Army Corps of Engineers to remove over three million cubic yards of debris in just a few months.¹⁹² Second, the school system was able to find replacement facilities for the school buildings that were lost in the storm, allowing students to return to school on schedule. Third, a hospital sponsor agreed to build a new hospital in Joplin and retain all hospital workers in Joplin until the facility opened. This was done in partnership with an unaffected hospital in the area to keep up with demand. Finally, a group of civic leaders formed an organization called the Citizens Advisory Recovery Team (CART) for long-term recovery planning. This group consisted of volunteers from multiple sectors of the community, working on essential recovery needs throughout Joplin.¹⁹³ They also served as a liaison between the community and the city. Tonya Sperkle, CERT member, stated,

¹⁹¹ Ibid., 22.

¹⁹² Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 2.

¹⁹³ Ibid., 2.

“CART can also be called the watchdog. We know what was promised by the city and we are there to ensure these promises are kept.”¹⁹⁴

Other community groups that assisted Joplin include the Jasper and Newton Counties Community Health Collaborative, Ten for Joplin, and the Community Foundation of Southwest Missouri. The Community Health Collaborative involves representatives from both of the hospital systems, the city and county health departments, the United Way, and other organizations interested in promoting health.¹⁹⁵ Additionally, the Habitat for Humanity out of Tulsa, Oklahoma, created the rebuilding effort in Joplin called Ten for Joplin. As a neighboring jurisdiction, it immediately jumped in to assist. Members worked for over 10 months and raised over one million dollars to help rebuild homes lost in the disaster.¹⁹⁶

Relationships between the citizen-led community groups, local officials, the State of Missouri, and FEMA were already well established before this disaster, creating relationships based on trust and mutual understanding.¹⁹⁷ Due to the number of interjurisdictional relationships, and the degree of trust in these groups to do what was best for the city of Joplin, more was accomplished in a shorter amount of time. Additionally, the number of groups working on different goals as part of a larger system illustrates the concept of compartmentalization as outlined in the fragility literature. The emergency management agency was able to work through broad goals while the community-led groups were able to work on specific recovery actions for their areas of expertise. In the case of Joplin, this model was highly successful overall. This also illustrates flexibility in planning efforts and the ability to adapt to the disaster environment. Instead of maintaining the hierarchical structure as outlined in their emergency operations plan, community members were able to effectively branch out horizontally to multiple organizations to work through recovery efforts.

¹⁹⁴ Preussner, *Examination of FEMA*, 26.

¹⁹⁵ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 15.

¹⁹⁶ *Ibid.*, 25.

¹⁹⁷ Preussner, *Examination of FEMA*, 31.

Another key area for the stability of a community is strong leadership and local governance. Joplin is governed by a nine-member elected council, including a mayor, and has an established city manager to work through the day-to-day government business. Joplin has also had an emergency management program in place since the 1950s, led by an emergency management director.¹⁹⁸ Mark Rohr, City Manager, remarked after the disaster,

I have been in cities in which we dealt with storms and the damage incurred, but nothing remotely like this. It was overwhelming—I was overwhelmed for a brief moment, but I knew that we had to get to work immediately. I took a deep breath, told myself that if the City was going to recover, we needed to get to work—and that’s what we did.¹⁹⁹

This statement exemplifies the common attitude amongst the key officials throughout the city. This leadership philosophy enabled partner organizations to work without the fear of “stepping on toes” or impeding progress, and the leaders provided calm, supportive reassurance throughout the disaster.

This was also true at the state level. Many commented on the visibility and leadership of the governor, Jay Nixon. While outlining the state recovery goals, the governor stated, “As a state, we are deploying every agency and resource available to keep Missouri families safe, search for the missing, provide emergency medical care, and begin to recover.”²⁰⁰ The governor secured funds immediately for the wide-scale efforts for debris removal and for a pediatric treatment facility. Additionally, Nixon provided state income tax credits to encourage voluntary donations toward disaster relief operations. Gary Duncan, Chief Executive Officer of Freeman Health System, reiterated the positive comments of many others. He stated, “The governor was a huge part of the

¹⁹⁸ “Joplin Jasper County Emergency Management Agency,” Joplin, Missouri, <http://www.joplinmo.org/index.aspx?nid=154>

¹⁹⁹ Cage, and Serino, *Joplin Pays It Forward*, 12.

²⁰⁰ Nathan Busch, and Austen Givens, “Achieving Resilience in Disaster Management: The Role of Public-Private Partnerships,” *Journal of Strategic Security* 6, no. 2 (2013): 1, <http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1231&context=jss>

momentum down here. He was here every other day. He was saying ‘Let’s get ‘er done.’”²⁰¹

The current literature regarding this disaster agrees that strong leadership existed in Joplin at the time of the tornado and that the local officials were present, visible, and able to manage the emergency effectively. Mark Rohr stated,

It comes down to the local leadership. We are the ones setting the pace, and these agencies are working for us. And they do, but you have to provide the direction in where you want them to go. They will tell you that they can enhance local leadership, but they cannot take its place.²⁰²

4. Joplin Community—Sustainability

Sustainability involves the community’s ability to continue moving forward through a disaster, into recovery and beyond. This involves resource management practices, restoration of lifelines, and the ability to recognize small system failures that could lead to cascading events. There is nothing in the literature to suggest that system failures occurred in Joplin that went unnoticed or that cascading events occurred that caused full system failures; however, information is available on the other three key indicators of community fragility due to sustainability.

Telephone communications to the city were largely cutoff after the tornado, causing difficulty in for officials to obtain situational awareness about the damages and community needs.²⁰³ Additionally, roads and bridges were blocked by debris, cutting off access to the hospital and other critical facilities. The city set a goal of August 17 to get all critical infrastructure repaired since school would begin that day. With the help of the U.S. Army Corps of Engineers, the city was able to meet this deadline as well as the

²⁰¹ Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 14.

²⁰² Cage, and Serino, *Joplin Pays it Forward*, 12.

²⁰³ Michael Todd Gardner, Cory Beard, and Deep Medhi, “Avoiding High Impacts of Geospatial Events in Mission Critical and Emergency Networks Using Linear and Swarm Optimization,” in *2012 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA)* (2012): 264, http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6188395&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D6188395

deadline of August 6 for the completion of all debris removal operations.²⁰⁴ Additionally, because of the loss of one of the two hospitals in the city, a temporary hospital was set up within one week of the disaster to assist with surge capacity. After three months, the field hospital was transitioned to a modular unit and within a year a new facility was opened with 120 beds.²⁰⁵

The ability to work collectively to repair and restore critical infrastructure is directly connected to the city's ability to obtain the necessary resources for recovery. Without the assistance provided by multiple private and public partners in the hours, days, and weeks following the disaster, Joplin would not have had the supplies and resources necessary to rescue survivors, clear roads, and repair damaged infrastructure. According to research done by Busch, and Givens, Home Depot and Wal-Mart each pledged to give one million dollars to the recovery effort. Additionally, Home Depot partnered with Delta Airlines to fly in over 200 volunteers from businesses in Georgia to deliver supplies throughout the city. Moreover, the Empire District Electric Company partnered with neighboring power companies to restore power and natural gas to the city residents, and Sprint provided cellular phones and satellite phones to emergency officials, allowing them to remain connected.²⁰⁶

Just as importantly, however, the Joplin disaster illustrated the recovery concept of neighbors helping neighbors. Daniel Aldrich, Purdue University, states,

Survivors of tornadoes in the Midwest need to borrow water, chainsaws, diesel generators, and other equipment that they do not own and are not available due to the closure of stores. Neighbors and friends—not government agencies or NGOs—provide the necessary resources for recovery after disaster.²⁰⁷

In the case of Joplin, Missouri, reports indicate that all of these groups assisted in a successful recovery.

²⁰⁴ Doug Scott, "2012 Critical Infrastructure Symposium Focuses on Resilience," *ASCE News*, May 2012, <http://cms.asce.org/ascenews/shorttakes.aspx?id=25769808621>

²⁰⁵ White House, "Joplin: One Year Later," The White House, accessed January 20, 2015, <http://www.whitehouse.gov/joplin>

²⁰⁶ Busch, and Givens, "Achieving Resilience in Disaster Management," 1.

²⁰⁷ Aldrich, "Fixing Recovery: Social Capital in Post-Crisis Resilience," 6.

The data available on resiliency after the storm coincides with all other information about this disaster. Joplin has shown the ability to be resilient. According to the Joplin Area Chamber of Commerce, over 500 businesses sustained damages in the Tornado, and six months into recovery, over 400 of those businesses had reopened, and another 46 reopened in the months that followed.²⁰⁸ Although 33 companies indicated that they would not rebuild, 21 new businesses have since opened in their place.²⁰⁹ As for residents of the area, Mayor Mike Woolston reported that 88 percent of the people displaced by the disaster had returned to the area and are living within 25 miles of the disaster. In addition, schools expected a dramatic decline in enrollment due to the disaster but found that 95 percent of students returned at the beginning of the school year. Sue Adams, with the Joplin Area Chamber of Commerce, stated that the hospital and the schools became “the icon of the rebuilding” because they immediately began the process of putting the city back together.²¹⁰

The focus did not end with rebuilding. The city formed recovery groups to look at ways in which Joplin could rebuild and become stronger in the process. Jane Cage, Missouri’s community disaster recovery leader, said, “We owe it to the people who died in Joplin, and the people who lost their homes, to rebuild better than we were. If we become only what we were before the tornado, it would be a shame.”²¹¹

5. Summary Analysis of Fragility for the Joplin Tornado

Overall, accounts regarding the 2011 Joplin tornado illustrate a tight-knit community, with high social capital, a flexible and adaptable emergency management program, and strong local leadership. The city uses an ICS model for emergency management, and welcomes various governmental, non-governmental, private sector and volunteer agency partners. Several interviews indicated that the community generally has

²⁰⁸ White House, “Joplin: One Year Later.”

²⁰⁹ Ibid.

²¹⁰ Ibid.

²¹¹ Joe Lamb, “Joplin Leaders Share Tornado Recovery Lessons with Faulkner County,” *The Cabin Net*, August 14, 2014, <http://thecabin.net/news/local/2014-08-14/joplin-leaders-share-tornado-recovery-lessons-faulkner-county#.VJ86wl4AA>

a “take care of yourself, don’t wait around for others to take care of you” approach.²¹² This attitude is apparent in multiple reports from the tornado, from neighbors helping neighbors, to local community groups stepping in to assist the city in recovery efforts.

An analysis of the conceptual framework for fragility in emergency management illustrates that the city of Joplin has high connectedness, stability, and sustainability, all factors to decrease overall fragility. Figure 18 further outlines each area of the framework specific to the 2011 Joplin tornado event.

²¹² Abramson, and Culp, *At the Crossroads of Long-Term Recovery*, 11.

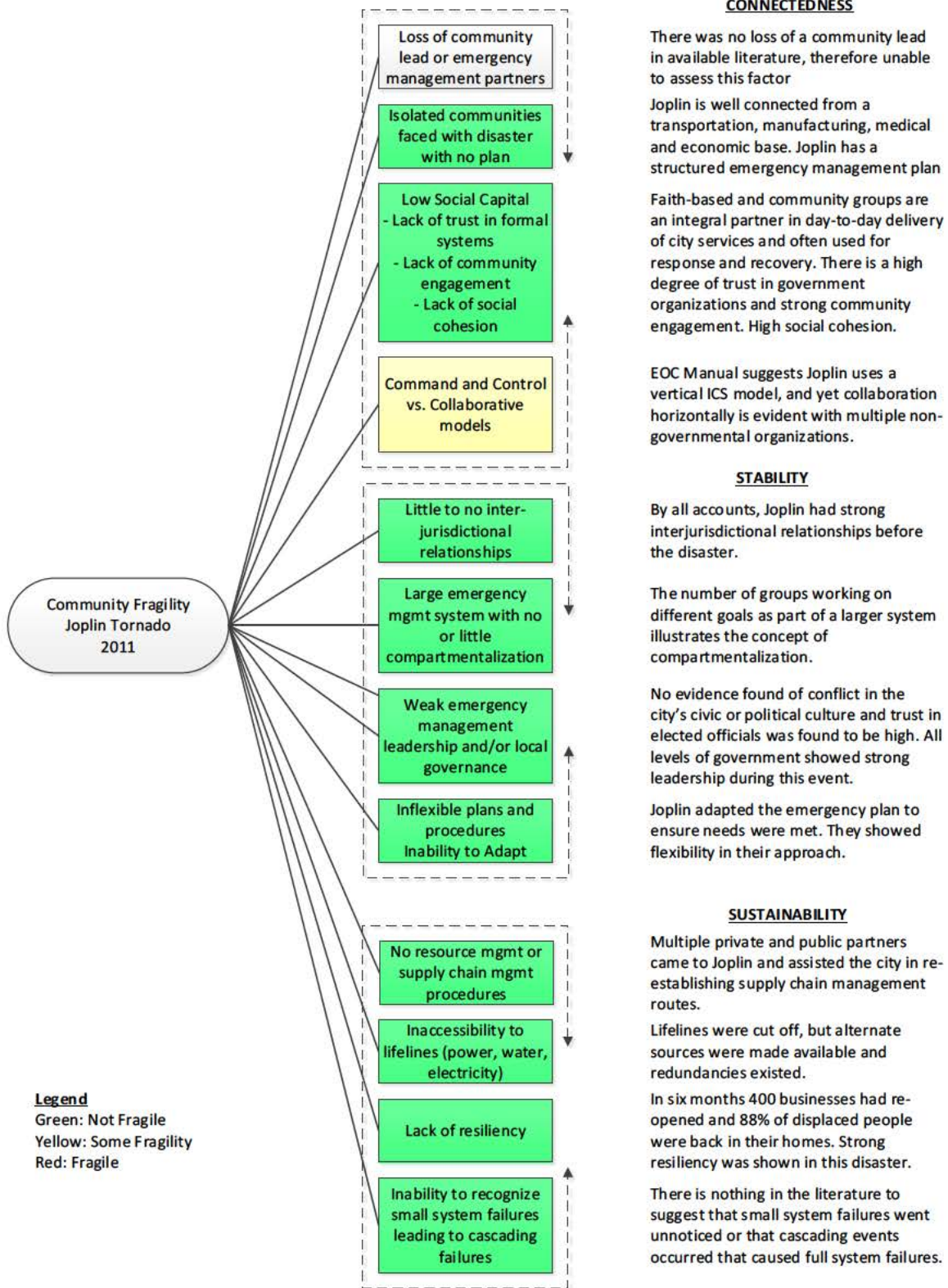


Figure 18. Fragility Framework—Analysis of the 2011 Joplin Tornado

Keith Stammer, Emergency Management Coordinator for Joplin, summed it up when he said,

We are but ordinary people who found ourselves in extraordinary circumstances. We stepped up to meet the challenge presented us. We have done what was needed in order to recover and restore. ‘Adjust, adapt, overcome’ is the mantra we continue to live by.²¹³

C. CASE STUDY 2: 2007 SAN DIEGO COUNTY WILDFIRES

“There was a desert wind blowing that night. It was one of those hot dry Santa Ana’s that come down through the mountain passes and curl your hair and make your nerves jump and your skin itch.”

–Raymond Chandler

1. Synopsis of the Event

Southern California is known for its wildfires, and there, they are as common as hurricanes in Florida or tornadoes in Kansas. Since 1956, there have been seven federally declared wildfire disasters, along with annual wildfires meeting the thresholds for the Fire Management Assistance Grant (FMAG) through FEMA.²¹⁴ The nature of wildfire in southern California is also quite different than the rest of the United States, both by nature and degree. California has the highest losses in property and life from wildfires annually, but it also has the highest number of people moving into the wildland-urban interface where wildfires are most destructive.²¹⁵

Because of this history, all 58 counties and nearly all city governments in California signed a master mutual aid agreement for wildfire management in 1950.²¹⁶ After the devastating wildfire season in 1970 and criticism regarding a lack of

²¹³ Cage, and Serino, *Joplin Pays It Forward*, 22.

²¹⁴ Federal Emergency Management Agency [FEMA] and California Office of Emergency Services [OES], *Southern California Best Practices: Southern California Wildfires of 2007* (Mather, CA: Federal Emergency Management Agency and California Office of Emergency Services, 2008), <http://nhma.info/uploads/bestpractices/2007%20Wildfires%20-%20DR%201731%20CA%20-%20Best%20Practices.pdf>

²¹⁵ Jon E. Keeley, Hugh Safford, C.J. Fotheringham, Janet Franklin and Max Moritz, *The 2007 Southern California Wildfires: Lessons in Complexity* (Bethesda, MD: United States Geological Survey, 2009), <http://pubs.er.usgs.gov/publication/70036938>, 287.

²¹⁶ *California Fire Siege 2007: An Overview* (Los Angeles: California Department of Forestry and Fire Protection, 2008), http://www.fire.ca.gov/fire_protection/downloads/siege/2007/Overview_CompleteFinal.pdf, 8.

cooperation and accountability in response, state and federal funding was made available for a five-year research project called Firefighting Resources of Southern California Organized for Potential Emergencies, better known as FIREScope. The research team identified a new fire management system composed of the following key elements: Incident Command System, Multi-Agency Coordination System, Information Management System, Technological Support, and Common Communication. This would later become the basis for the National Incident Management System.²¹⁷

Although California had long faced major wildfires and had helped to create the incident management systems that have been used nationally for decades, the 2007 wildfire season exceeded state capabilities and severely taxed current plans and procedures. The San Diego Firestorms were the largest in county history, far surpassing the devastating 2003 wildfire season, which had previously been the worst on record.²¹⁸

Rainfall totals that year were far below average, leaving California drier than normal at the beginning of the fire season. Summer weather continued to be dry with very little precipitation, increasing the potential for severe fires in the fall. Beginning in mid-October 2007, Predictive Services at the Southern California Geographic Area Coordination Center (OSCC) began forecasting an “extreme fire weather event of strong, hot, dry, winds.”²¹⁹ Fire managers monitored the weather and as the winds increased, they pre-positioned federal firefighting resources, including Incident Management Teams, air resources, and 24-hour staffing of fire personnel.

California fire managers understand that coordinating firefighting efforts during a “fire siege” is drastically different than a typical wildfire. Due to the force and nature of the Santa Ana winds, these wildfires are highly unpredictable. The winds, coupled with the dry, heavy fuels, increase the number of wildfires in the area and cause the fires to

²¹⁷ Sheron Morgan, Marian Mosser, and Phillip Paker, *Wildfires in California: Analysis of the Incident Command System and FIREScope* (presented at Cambridge Business and Economics Conference, 2011), http://www.gcbe.us/2011_CBEC/data/Sheron%20Morgan,%20Marian%20Mosser,%20Phillip%20Paker.doc, 6.

²¹⁸ Walter Ekard, Harold Tuck, and Ron Lane, *San Diego County 2007 Firestorms after Action Report* (San Diego, CA: County of San Diego, 2007), http://www.sandiegocounty.gov/oes/docs/2007_SanDiego_Fire_AAR_Main_Document_FINAL.pdf, iv.

²¹⁹ Ibid.

grow out of control quickly. The wildfires move like a storm front, called a firestorm, and can shift direction randomly in any direction.²²⁰ In 2007, the Santa Ana winds blew up to 70 mph. This, combined with the high temperatures, low relative humidity, and dry conditions created the perfect environment for a major fire event.²²¹

The 2007 wildfires began at approximately 9:30am on October 21, 2007. The Harris Fire was reported along Highway 94 near the U.S.-Mexico border town of Potrero in San Diego County. Strong winds decreased suppression efforts, and the fire grew rapidly in dry brush and grass. Emergency management personnel quickly mobilized and activated their emergency operations center (EOC) just a few hours into the incident. As the incident progressed, more personnel were called in to assist. Personnel from over 60 disciplines were present, representing local, state, and federal governments, as well as non-governmental and non-profit partners. By mid-afternoon, a local disaster declaration had been sent to the governor's office.²²² There were reports of multiple structures burning and numerous injuries. Air firefighting efforts were also affected because of the low visibility and 70 mph winds in the area. In a little over 12 hours, the Harris Fire had already burned more than 16,000 acres (see Figure 19).²²³

²²⁰ *California Fire Siege 2007*, 60.

²²¹ Emergency Response and Crisis Management Technical Assistance Center, "Communication and Collaboration During Natural Disasters: The Lessons Learned from Past Experience," *Lessons Learned from School Crises and Emergencies* 3, no. 2 (2008), <http://eric.ed.gov/?id=ED504384>

²²² Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 8.

²²³ *Ibid.*

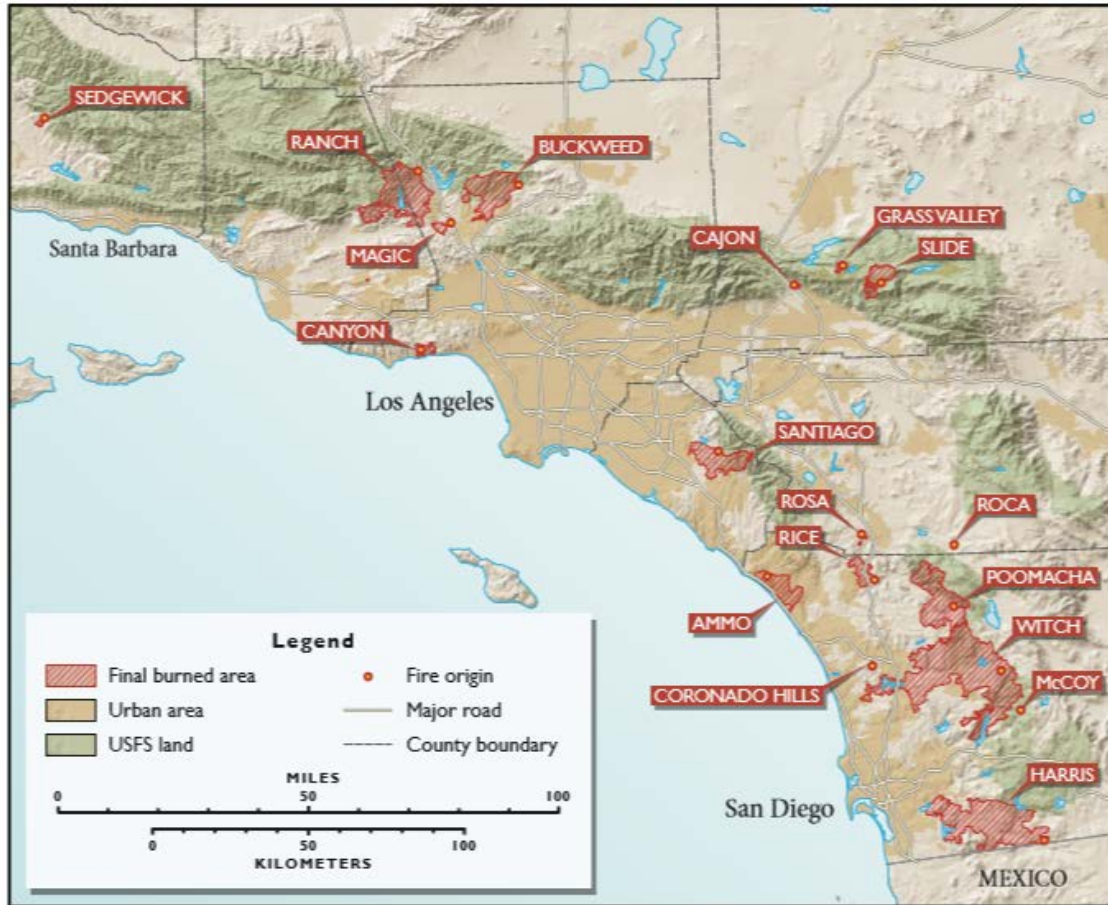


Figure 19. Fire Maps of the 2007 Southern California Fire Storms²²⁴

A mere 40 miles away, the Witch Creek Wildfire was reported at 2:35pm on the same day in a rural area east of Ramona in San Diego County. Due to the high winds and the inability of air resources to assist in combatting the blaze, the fire spread rapidly toward heavily populated communities. Rates of fire spread exceeded 5 mph in some areas and flame lengths were often 80–100 feet high. Locals in the area of the Witch Fire reported winds in excess of 100 mph.²²⁵

Each incorporated city within San Diego County has the ultimate authority for wildfire management within their boundaries. State, tribal, and private lands in unincorporated areas of the county are managed by the California Emergency

²²⁴ *California Fire Siege 2007*, 66.

²²⁵ *Ibid.*

Management Authority (Cal EMA), previously known as CAL FIRE, and federal lands are managed by the federal land agencies, such as the U.S. Forest Service or the Bureau of Land Management. All agencies utilize their own resources before calling on neighboring jurisdictions as part of the San Diego County Fire Mutual Aid Agreement and the State Master Mutual Aid Agreement. Furthermore, San Diego officials formed a fire authority in June 2008 to improve fire protection and emergency medical services throughout the county. They also contract with local fire protection districts and volunteer fire departments to provide fire suppression and medical services.²²⁶

With multiple fires already burning throughout Southern California, resources were already stretched thin. By evening, the fire jumped Interstate-15 and burned over 10,000 acres.²²⁷ Multiple structures were reported destroyed in Rancho Bernardo and Poway. The Witch Creek Wildfire became the most destructive of the 2007 season, and as it grew in size, it joined the Poomacha Fire in the north and together the two fires burned 247,400 acres and destroyed over 1,200 homes.²²⁸

The Guejito Wildfire began the next day, October 22, 2007, at 1:30am near the Wild Animal Park in San Diego County. It took only a few hours before the fire began consuming homes in northeastern Rancho Bernardo. It continued to spread west and jumped I-15, ultimately destroying hundreds of homes in West Rancho Bernardo. While 365 homes were lost, it is estimated that over 6,000 were saved by aggressive firefighting actions taken by the fire managers on scene.²²⁹

The Witch Creek and the Guejito fires ultimately merged in the early morning hours of October 22, 2007, as the temperatures increased. This led to the largest evacuation in the county's history, where more than a half a million people were ordered to leave the area. The San Diego Mayor, Jerry Sanders, and the Chief Operating Officer,

²²⁶ *Operational Area Emergency Plan: Wildland/Urban Interface Fire Annex* (San Diego: Unified San Diego County Emergency Services Organization and County of San Diego, 2011), http://www.wildfiremethods.com/linked/final_wildland-urban_interface_fire_annex.pdf, 7.

²²⁷ Ibid.

²²⁸ FEMA and OES, *Southern California Best Practices*, 5.

²²⁹ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response* (San Diego: City of San Diego, 2007), http://www.sandiego.gov/fire/pdf/witch_aar.pdf, 6.

Jay Gladstone, were kept updated regarding the advance of the fires into heavily populated areas of the city of San Diego. Mass notifications and evacuation plans were put into effect with an estimate of the fires reaching the city limits by 5am on October 22. Geographical trigger points were utilized for neighborhood evacuations to ensure a timely and controlled evacuations. Furthermore, police officers staged at various points throughout the city to assist in compliance with evacuation orders.²³⁰

Short-term recovery operations began in the Operational Area Emergency Operations Center (OAEOC) with the establishment of a recovery coordinator to assist in the development of the recovery organizational structure. This group focused primarily on damage assessments in unincorporated areas of the county and the formation of four local area assistance centers (LACs). Each LAC provided a single point of contact for displaced and affected community members to get assistance and support from local, state, federal, and non-governmental agencies.²³¹

In four days, the Santa Ana winds contributed to 23 separate southern California wildfires before finally dying down and allowing firefighters to battle the blazes. At the height of the firestorms, there were seven separate wildfires burning in San Diego County alone. These fires resulted in the deaths of 10 civilians and injuries to 89 firefighters. More than 6,200 personnel assisted in controlling these fires, which all together consumed over 13 percent of the county's land mass.²³²

2. San Diego County—Connectedness

The four components of connectedness include: isolation of the community, lack or surplus of social capital, the effect of a loss of a community leader, and the emergency management organizational model utilized during and after response. Out of these four components of fragility, the two areas that stand out for the 2007 San Diego firestorms are elements of social capital specific to vulnerable populations, and command and control mechanisms specific to wildfire. Similar to the incident in Joplin, San Diego

²³⁰ Ibid., 5.

²³¹ Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 67.

²³² Ibid., iv.

County did not experience the loss of a key community leader, making it impossible to evaluate the consequences of such a loss. San Diego is also not an isolated community. The area is surrounded by populated communities, various access routes, and a robust wildfire management system throughout the county and the state of California.

San Diego County had a population of approximately 3.2 million people at the time of the 2013 U.S. Census.²³³ Unlike Joplin, San Diego County is incredibly diverse in terms of ethnicity and other demographics. The majority of the population is Caucasian at 62 percent, but the county also has large populations of Asian, African American, Filipino, and Hispanic ethnicities.²³⁴ One-third of San Diego County has a Hispanic and Latino population, and approximately 70 percent of the wildfire burn area was populated with this group of people, including groups of immigrants and migrant farm workers from Mexico.²³⁵ Due to this diversity, it was easier to evaluate various degrees of social capital and isolation of a specific group of people.

In 2002, the United States Department of Agriculture published a report titled, *Homeowners, Communities, and Wildfire: Science Findings from the National Fire Plan*. In that report, it recognized the value of social capital in improving community preparedness specific to wildfires.²³⁶ After the 2003 Cedar Wildfire in San Diego County, the county made several strides to ensure diverse populations were considered in evacuation actions. Particularly, planning and preparedness efforts went toward strengthening communications with the disability community and others with access and functional needs.

In the 2007 fire siege, multiple organizations began working to ensure these populations were considered and that their needs were met. Many skilled nursing

²³³ Ibid.

²³⁴ United States Census Bureau, "American Fact Finder," accessed January 20, 2015, <http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>

²³⁵ Nadia Siddiqui, Dennis Andrulis, and Guadalupe Pacheco, "Southern California Wildfires of 2007: Preparing and Responding to Culturally and Linguistically Diverse Communities," in *Case Studies in Public Health Preparedness and Response to Disasters*, ed. Linda Young Landesman, Isaac B. Weisfuse (Burlington MA: Jones and Bartlett Learning, 2013), 22.

²³⁶ Aldrich, "Fixing Recovery: Social Capital in Post-Crisis Resilience," 10.

facilities had to be evacuated to shelters and evacuation points. Due to the pre-planning by the Office of Emergency Services and Health and Human Services personnel, these actions went smoothly. Additionally, patients from three hospitals and 12 nursing homes were evacuated. Medical resources were also deployed to provide medical care at each shelter.²³⁷ However, one problem that was noted was that there was not a coordination point for these agencies to collaborate. Therefore, while people with disabilities or medical conditions were considered and helped, many agencies were unaware of the actions or decisions of other agencies, which caused confusion.

Overall, many applauded San Diego County for its quick response to the wildfire and its effective evacuation of citizens. However, many community organizations reported that there were serious gaps with sections of the community, specifically with regard to culturally and linguistically diverse populations.²³⁸ More than one-third of the county's residents reported receiving no warning or communications regarding the wildfire or evacuations. This included homes on Native American reservations and those located in remote areas of the county.²³⁹ Other barriers to communication occurred in evacuation and sheltering operations. This was mainly due to one of the three key areas of social capital: trust. These barriers led to delays in key services, the loss of jobs and homes, health concerns, and other damages.

An after action report for the City of San Diego stated,

The safety and security of the people who seek the City's protection is our Number One priority. This is for all people seeking protection from the firestorm, irrespective of unknown or questionable residential, immigration or other status. Everyone had the opportunity to be safe.²⁴⁰

But one of the primary areas where trust was a factor was in the sheltering of migrant workers and illegal immigrants. One example, leading to many not evacuating or seeking shelter, was the relationship San Diego County had with the U.S. Customs and Border

²³⁷ Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 56.

²³⁸ Ibid.

²³⁹ Siddiqui, Andrulis, and Pacheco, "Southern California Wildfires of 2007," 22.

²⁴⁰ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response*, 27.

Patrol. The county invited the Border Patrol to assist in the wildfire by providing mapping services on the burn area. And although Border Patrol agents were not at the shelter site in an immigration capacity, the presence of their vehicles and the presence of personnel with Border Patrol uniforms created fear and anxiety among the migrants, who feared the agents would arrest them, which led to a breakdown in successful evacuation. Additionally, many in the community reported that San Diego police officers walked through the shelters at night asking people for their identity documents.²⁴¹

Military personnel and their families are also a large part of the San Diego community. During the fires, the Navy opened several evacuation centers at three naval bases in San Diego to provide support to these families. It also provided logistical support to local shelters in the form of cots and tents at Qualcomm Stadium and the fairgrounds. Although the military is an integral part of the San Diego community, there were communications breakdowns, however, between the civilian shelters and the military centers. For example, military personnel deployed to the area were unable to contact family members who were not located in military shelters but who had been evacuated to civilian shelters.²⁴²

On the positive side of social capital, there were many community groups that came to assist. When they found out about the difficulties with sheltering diverse populations and the communications concerns, advocacy and community groups mobilized resources to fill any unmet needs within the community.²⁴³ For example, church organizations opened their doors and provided shelter to those who did not trust official shelter locations. Having these organizations available and ready to assist during this disaster allowed for the successful evacuation of thousands of people. Additionally, the county recognized that there was a gap in the communications during this incident and has made significant strides in this area for future operations. Seventeen of the 21 recommendations outlined in the after action report for the county tied to better

²⁴¹ San Diego Immigrant's Rights Consortium and American Civil Liberties Union, San Diego and Imperial Counties Chapter, *Firestorm: Treatment of Vulnerable Populations During the San Diego Fires* (San Diego: San Diego County, 2007), <http://trove.nla.gov.au/work/38026325?selectedversion=NBD46043713>, 5.

²⁴² Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 48.

²⁴³ Siddiqui, Andrulis, and Pacheco, "Southern California Wildfires of 2007," 35.

communications. This ranged from ensuring people have the right information regarding evacuations to a multi-phased citizen preparedness campaign.²⁴⁴ The county also plans to increase the number of “partner relay” agencies from 150 to 300. This program was specifically designed to get evacuation notices to the many diverse communities throughout the area by utilizing religious organizations, community groups, and schools. Holly Crawford, Director of Emergency Services for San Diego County, said, “It’s important for us to reach everyone. Particularly paying attention to more vulnerable populations, we have an interest in reaching those individuals.”²⁴⁵

Another primary consideration when looking at the fragility of emergency management systems is an examination of the emergency management structure. As stated previously, California is responsible for creating the Incident Command System (ICS) that led to the National Incident Management System, which is now a standard across the nation. ICS includes five functional areas: command, operations, planning, logistics, and finance. Many law enforcement agencies have added another layer for field intelligence in law enforcement operations.

Under the ICS, the incident commander has the ultimate authority for the incident. This typically involves one agency as command with others falling into the various positions within the hierarchy. Agency administrators from other jurisdictions may be incorporated into the ICS as needed to ensure cooperation throughout the incident. This allows for a seamless transition in the event a wildfire spreads into other jurisdictions.²⁴⁶

ICS was also built to be expandable and flexible, to be used on any wildfire incident, large or small.²⁴⁷ In our new complex environment, where large populations are living in forested areas, the numbers of partners have grown exponentially. This has led to an expanding structure of incident command, including multi-agency coordination centers (MACCs), emergency operations centers (EOCs), joint information centers

²⁴⁴ Ari Bloomekatz, “How the County Wants to Fix Wildfire Response,” *Voice of San Diego*, June 17, 2014, <http://voiceofsandiego.org/2014/06/17/how-the-county-wants-to-fix-wildfire-response/>

²⁴⁵ Ibid.

²⁴⁶ *Operational Area Emergency Plan*, 5.

²⁴⁷ Morgan, Mosser, and Paker, *Wildfires in California*, 10.

(JICs), and other coordinating elements. In the case of the 2007 San Diego firestorms, the incident commander communicated with the local EOCs for each jurisdiction. They also used multiple fire communications centers (FCCs) for resource ordering, situation status cells for intelligence operations and spatial analysis, department operations centers (DOCs) for law enforcement coordination, and JICs for communicating with the public.²⁴⁸ These groups are not necessarily under the command of the incident commander, but instead coordinating groups acting together on the incident. Therefore, while San Diego County utilizes the ICS model of command and control for incident operations, it also uses it with the flexibility to bring in partners that are most needed for the successful execution of the mission.

3. San Diego County—Stability

Stability is assessed by looking at relationships, leadership, plans, and the structure of the emergency management system. As illustrated in the previous section, San Diego has a robust emergency management system that utilizes a hybrid approach, combining the command and control model of ICS with the horizontal model of collaboration. Additionally, there are many “hubs” or groups that work throughout the area in various functions, such as information management, shelter operations, law enforcement actions, etc. For law enforcement alone, the county reported that the San Diego Police Department Operations Center (DOC) worked with Eastern Command, Traffic Command, Southern Command, Northeastern Command, and Headquarters Staging to provide scene security, traffic control, evacuation operations, and overall law enforcement coordination.²⁴⁹ However, difficulty with this model is that the connection points between these groups are not always strong, leading to breakdowns in communications. It is also challenging having so many groups called “command” as it causes confusion with the public and support entities as to who is really in charge. From a stability perspective, having a compartmentalized structure can lead to better overall

²⁴⁸ *Operational Area Emergency Plan*, 5.

²⁴⁹ Michael Dombeck, Jack Williams, and Christopher Wood, “Wildfire Policy and Public Lands: Integrating Scientific Understanding with Social Concerns across Landscapes,” *Conservation Biology* 18, no. 4 (August 2004): 888.

management of the incident as different partners will focus on diverse areas of need. However, as was expressed in multiple after action reports, it is equally important to build the bridges between these organizations to ensure communications remain strong.

San Diego County has shown its ability to adapt and to create flexible planning models for the future. Literature regarding the Cedar Fire in 2003 outlined various lessons learned that have since been implemented within the community to make them stronger for the next disaster. This greatly enhanced the emergency management system for the 2007 firestorms. For example, newly developed city, county, and community evacuation plans were utilized for the first time in the 2007 wildfires, assisting the San Diego County Sheriff's Office execute the largest single fire evacuation in the nation's history. Again, when these fires ended, the wildfire and emergency management communities captured new lessons learned and have shown their willingness to adapt plans and procedures to decrease their fragility in the future.

Additionally, traditional approaches to incident management and the ICS involved military models that were much less flexible than what is seen today. These military officers modified military command and control models for the wildfire arena to meet the needs of the communities affected. However, over time, adaptation and flexibility were needed to make the model work in large-scale disasters involving multiple jurisdictional authorities. According to Morgan, Mosser, and Paker, "This adaption process was not seamless, nor did it occur rapidly. In fact, both emergency services incident command theory and military sciences continue to evolve."²⁵⁰

The two areas with the most literature regarding fragility measures include interjurisdictional relationships and leadership. Much like Joplin Missouri, San Diego County has a wealth of partnerships with public and private partners. One of the San Diego after action reports states, "The 2007 firestorms demonstrated that the working relationships and coordination in this region have never been better between the city and the county."²⁵¹ Some of these partnerships are formal, specific to wildfire management

²⁵⁰ Morgan, Mosser, and Paker, *Wildfires in California*, 4.

²⁵¹ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response*, 1.

with various state and federal wildfire managers, while others are less formal relationships with community groups and the private sector.

The American Red Cross plays a primary role in sheltering operations for emergency incidents throughout California. The local Red Cross chapter was severely taxed during the initial days after the first few fires broke out in San Diego County. It did not have the staff or the resources to manage such a large event. With the assistance of other volunteer organizations, however, 45 shelters were opened and operated throughout the county, including two mega-shelters: one at Qualcomm Stadium and the other at Del Mar Fairgrounds. Additionally, over 3,000 animals were rescued, housed, and fed for over a week while people remained evacuated.²⁵²

San Diego County has strong relationships with all 42 school districts within the county, which became an important partnership during this incident. The Valley Center-Pauma Unified School District closed schools on Monday, October 22, 2007, due to dangers posed by the wildfires. That same day, the school district was asked to open an evacuation center at the Valley Center High School. By noon, the center already had 300 evacuees, and by the next day that number swelled to over 1,000 due to the start of the Poomacha wildfire.²⁵³ This influx of people to the high school was overwhelming, and since Red Cross resources were already stretched thin, school officials ran the center for several days. At one point, all roads leading to the school were closed due to wildfires surrounding the area. Members of the community brought in food and supplies and the school continued to handle the increasing number of evacuees for over one week.²⁵⁴ This ability to coordinate with multiple volunteer organizations and community partners greatly reduced the fragility of San Diego County during the wildfires.

Strong leadership was also shown throughout these fire events by all levels of government. Because of the anticipated number of evacuees throughout the county, the mayor made a decision early in the disaster to establish a mass evacuation center operated

²⁵² Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, v.

²⁵³ Ibid.

²⁵⁴ Emergency Response and Crisis Management Technical Assistance Center, "Communication and Collaboration During Natural Disasters," 6.

by city staff and volunteers until the Red Cross was able to bring in national resources to take over. Because other shelters were being forced to close due to additional evacuations, the city prepared to receive up to 100,000 people at Qualcomm Stadium.²⁵⁵ Other significant policy decisions that assisted residents include the early declaration of disaster by the mayor requesting state and presidential declarations, the dissemination of information to the public with instructions for people affected by the event, the delivery of resources to field personnel allowing them to continue response efforts, and the establishment of a city-run Local Assistance Center as a one-stop location for community members to get information about recovery resources.²⁵⁶

In addition, San Diego had state- and federal-level support. Governor Schwarzenegger made himself available to fire managers and other policy makers throughout the course of this event. He flew out to each fire base to meet with local officials and to determine the greatest needs so that he could pass along the information to the federal government partners. The state quickly assessed the situation and was able to provide the necessary information to FEMA for a presidential declaration, which was requested on October 22, 2007. President Bush signed Disaster Declaration 1731-DR-CA on October 24, and federal resources were immediately made available to assist local responders and agencies.²⁵⁷

4. San Diego County—Sustainability

Fragility factors related to sustainability include a lack of resource management procedures, inaccessibility of lifelines, lack of resiliency, and the inability to recognize system failures when they occur. Sustainability measures are a key topic of discussion amongst wildfire managers and emergency managers due to the number of people living in the wildland urban interface (WUI), the parched forests, and the overgrowth of tree stands due to decades of fire management practices that avoided the natural wildfire cycle. The 2007 San Diego firestorms provide prime examples of how resource

²⁵⁵ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response*, 7.

²⁵⁶ *Ibid.*, 8.

²⁵⁷ *California Fire Siege 2007*, 63.

management procedures and resiliency projects can decrease the overall fragility of a community over time.

The Incident Command System is an example of a tried and tested model for resource management practices. One of the primary reasons the ICS was created was to reduce duplication of efforts and decrease overall wildfire costs through proper resource management. The addition of emergency operations centers and multi-agency coordination centers have increased the capacity of fire managers to acquire necessary supplies and equipment to provide successful response and recovery support. In California, several additional measures have been taken to ensure this vital task is accomplished effectively. One example is the Emergency Managers Mutual Aid (EMMA) agreement, which provides emergency management personnel assistance to affected jurisdictions. Activation of the EMMA during the San Diego firestorms resulted in seven additional personnel deployed to the operational area EOC to provide overhead support in operations, planning, and intelligence functions.²⁵⁸

Another strength of the response actions during the firestorms involved the pre-positioning of resources throughout California in anticipation of a challenging fire season. With predictions of severe fire weather, including high heat, low humidity, and severe winds, fire chiefs throughout the region built up firefighting resource depth. Firefighters were moved into southern California prior to the start of the first wildfire and resources were increased after the fires began. As the wildfires progressed, other state and federal resources were deployed, as well as firefighting resources from Mexico.²⁵⁹

Even with these measures, resources were severely strained during the first few days of the fire siege. One report noted,

The experiences of the 2003 Cedar Fire and this 2007 Firestorm have confirmed that during periods of high fire activity in southern California, the State fire mutual aid system's ability to fulfill all resource requests during the critical first 48–72 hours will be severely challenged.²⁶⁰

²⁵⁸ Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 28.

²⁵⁹ *California Fire Siege 2007*, 62.

²⁶⁰ *Ibid.*

This was mainly due to the number of fires burning throughout southern California causing resource exhaustion and competing needs in the region. The recommendation for future operations is a “surge capacity” plan, involving additional ground and aerial resources.²⁶¹

This series of wildfires also saw the first activation for the state of California of the Emergency Management Assistance Compact (EMAC), which is a state-to-state mutual aid agreement allowing governors to request resources from other states. Since California utilizes both the ICS as well as Emergency Support Functions as outlined in the *National Response Framework*, these outside resources were easily able to integrate into existing incident management operations.²⁶²

The Operational Area EOC activated a robust logistics section that was responsible for managing incoming resource requests and providing situational awareness regarding resource needs and status. The team consisted of members of the Office of Emergency Services (OES) staff, facility personnel, purchasing agents, buyers, and off-site personnel at the primary warehouse for distribution. Emergency agreements were utilized to work with vendors on unmet resource needs. Approximately, 978 resource requests were made and filled during the EOC activation.²⁶³

Lessons learned from the 2007 firestorms outline several areas where logistical support could be enhanced. It was reported that several fire engines were unable to switch out hose and leave hoselays in place since there was no replacement hose available.²⁶⁴ Additionally, it was determined that a lack of a pre-determined number of fire apparatus required for large-scale wildfires led to a deficiency in fire apparatus for other events outside of the scope of this disaster. It is important to ensure that each jurisdiction has the resources required to handle day-to-day events while also supporting incident operations for wildfires in other areas.²⁶⁵

²⁶¹ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response*, 23.

²⁶² *California Fire Siege 2007*, 63.

²⁶³ Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 27.

²⁶⁴ City of San Diego, *After Action Report: October 2007 Wildfires City of San Diego Response*, 11.

²⁶⁵ *Ibid.*, 21.

It was also found that the Incident Management Teams were not utilized to their full capacity and the EOC should add positions to provide better support. This would have eased the burden on incident managers, and it would have allowed the teams and EOC to stay ahead of the incident instead of falling behind. Positions noted in the San Diego County after action report include: a medical unit leader for firefighter medical care, a recovery liaison to begin planning recovery operations, a volunteer manager to oversee critical functions of volunteer coordination, and a donations manager to manage the influx of donations into the city.²⁶⁶

Coordination with informal partners for resource management also had its strengths and weaknesses. To handle the significant donations from individuals as well as corporations, a logistics distribution center was established at Qualcomm Stadium. This provided countywide support to shelters, command posts, and base camps in the form of food, water, and necessary supplies. However, heavy evacuee traffic throughout the area caused major traffic difficulties and hampered the ability of workers to process deliveries, causing the county to re-examine supply chain management operations in the future.²⁶⁷

San Diego County recalled Community Emergency Response Team volunteers as well as academy recruit personnel to support emergency operations. The county also assigned special events staff to the evacuation shelter at Qualcomm Stadium because of their knowledge of the stadium and their ability to provide logistical support in a wide variety of areas. These groups proved to be extremely valuable in providing ongoing logistical assistance. Additionally, corporate sponsors, such as Wal-Mart, provided staff to manage inventory needs on a 24-hour basis in coordination with the EOC.²⁶⁸

One of the primary components of community fragility as outlined in the conceptual framework under sustainability is the inability to recognize small system failures leading to a cascade. From the information available on supply chain management and resource management, it appears that San Diego County was able to

²⁶⁶ Ibid., 22.

²⁶⁷ Ibid., 8.

²⁶⁸ Ibid., 29.

recognize small failures or gaps when they occurred, and it was able to correct them before any major challenges occurred. If logistical support had ceased at one of the mega-shelters, the incident had the potential to fail quickly. Instead, available reports suggest that when problems were identified, the county took appropriate measures to correct them. A primary example of this involves the restoration of lifelines. During the 2007 firestorms, power outages at the San Onofre Nuclear power plant and damages to SDG&E power lines threatened to cause a rolling black out throughout San Diego County. The state assisted the county by notifying the Navy, which returned all ships to port and worked off their own power supplies to decrease the demand. The ability of the Navy to provide this support allowed the county to maintain enough power to avoid the black out.²⁶⁹ Additionally, as mentioned previously, lessons learned after the disaster were given priority, and many solutions have already been implemented to ensure those problems do not occur again during the next disaster.

The final sustainability measure involves resiliency. This disaster provides several examples of how preparation efforts, wildfire mitigation, and education programs can decrease the fragility of the community for future disasters (see Figure 20). Since the 2003 Cedar Wildfire, San Diego County has invested over \$285 million in fire preparedness. County Supervisor Dianne Jacobs attributes this effort to saving homes and providing for the safety of residents in the 2007 firestorms. Ian MacDonald, Deputy Fire Marshall for the City of Orange Fire Department, agreed and added, “Jurisdictions need to understand their community and have fuel modification plans ready, so they can work closely with developers to avoid future problems.”²⁷⁰

²⁶⁹ Ekard, Tuck, and Lane, *San Diego County 2007 Firestorms after Action Report*, 48.

²⁷⁰ FEMA and OES, *Southern California Best Practices*, 23.



Figure 20. Pre-fire Mitigation Efforts Using Defensible Space Actions²⁷¹

New construction continues throughout southern California. Homeowners are attracted to the climate, the forested mountains, and the ocean views, leading more to purchase property in the wildland urban interface. This increases the vulnerability of the area to potentially catastrophic wildfires affecting residents of the area. To combat this problem, in January 2005, California passed a new state law that extended defensible space clearance requirements around homes and other structures from 30 feet to 100 feet. Where applied, these strategies for wildfire mitigation were successful. Homeowners, fire department personnel, and real estate agents all agreed that the “results spoke for themselves” after the 2007 wildfires.²⁷²

More than 2,460 multi-million dollar homes survived when the Witch Fire blew through the area. These homes were built to the highest construction standards, including extensive defensible space work around and within developed areas.²⁷³ Cliff Hunter, fire marshal for the Rancho Santa Fe Fire Department, said that developments within his fire area are governed by the strictest residential fire codes in the country.

²⁷¹ *California Fire Siege 2007*, 60.

²⁷² FEMA and OES, *Southern California Best Practices*, 4.

²⁷³ *Ibid.*, 17.

Other areas that require defensible space measures and that survived the 2007 firestorms include the Crosby, Cielo, 4SRanch, Bridges, and Bel Etage developments; this area is also known as the Santa Fe Valley. Wildfires in these areas burned up to the point where defensible space measures had been taken and then the fires stopped. Additionally, flying embers were unable to cause harm to the tile roofs and stucco walls, further strengthening the homes against wildfire. Furthermore, firefighters in these areas assist homeowners with wildfire education and by identifying trouble areas on private property that could cause fires to grow.²⁷⁴ Schools also pass out preparedness materials to students regarding defensible space and ways to mitigate against wildfire. This combination of strict codes, building standards, education, and preparedness efforts have saved many homes and other buildings during the 2007 firestorms and continue to be a best practice for public officials.

5. Summary Analysis of the San Diego Firestorms

Overall, the 2007 San Diego firestorms provide a strong example for the factors of community fragility outlined in the fragility framework. In this event sample, both strengths and weaknesses are available to illustrate how one factor can either contribute to or overcome community fragility. For example, there is high social capital and connectedness in San Diego County amongst most communities, but the low social capital of a few other communities, such as migrant workers and people with disabilities, led to a few system failures that now need to be addressed. Additionally, while San Diego County uses a command and control model for wildfire response, which has the potential to increase fragility, it also provides flexibility and adaptability within that model to account for other partners and organizations. This combination provides the county with the necessary authority structure while also honoring the collaboration of multiple non-governmental groups.

Probably the best example of decreasing fragility for a community available from this sample involves the degree of education, preparedness, and mitigation efforts to decrease overall risk. The partnership between government, real estate agents, building

²⁷⁴ Ibid., 18.

officials, fire management officers, and community members is extraordinary and was directly responsible for saving lives and homes in the areas of the wildfires.

Figure 21 on the following page provides a visual analysis of the 2007 San Diego firestorms, outlining each measure of fragility as described in the theoretical framework, along with specific comments for each measure. While the San Diego case study had a few more weaknesses in social capital than the Joplin example, most of the fragility factors were easy to examine and found to be strong in favor of a system with decreased overall fragility.

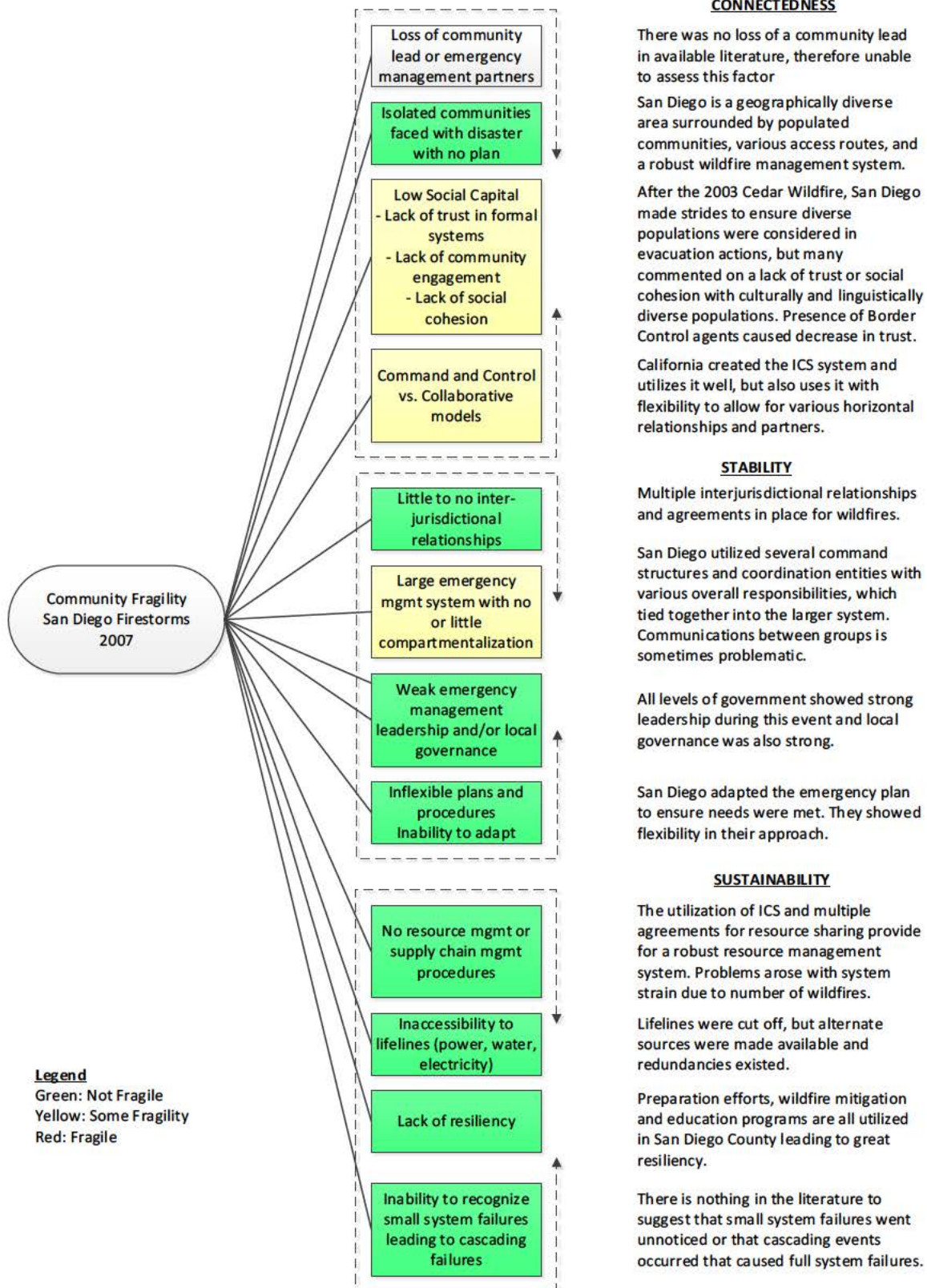


Figure 21. Fragility Framework: Analysis of the 2007 San Diego Firestorms

D. CASE STUDY 3: HURRICANE KATRINA, NEW ORLEANS, LOUISIANA, 2005

“Hundreds of heroes and leaders among the residents and responders helped save lives in flooded and wind-damaged communities, but those charged with responsibility to lead showed little leadership.”

–William Waugh

1. Synopsis of the Event

Due to the number of overwhelmingly negative reports and the number of lessons learned from the Hurricane Katrina disaster in New Orleans, Louisiana, it is assumed that the area would have a high degree of community fragility. Therefore, any research regarding fragility in emergency management would be incomplete without an analysis of this disaster to determine if the measures of fragility in the framework match such an assumption.

The tropical depression that became Hurricane Katrina first formed over the Bahamas on August 23, 2005. Meteorologists followed the storm and began warning people in the Gulf Coast States that a major storm was coming. By August 28, 2005, evacuations had begun across multiple states. The City of New Orleans was particularly at risk due to its topography. The average elevation of the city is approximately six feet below sea level and is surrounded on all sides by water. A system of levees and seawalls have been constructed by the U.S. Army Corps of Engineers over the years to protect the area. The levees along the Mississippi River were robust, but even before the storm, officials worried about the levees that hold water back from Lake Pontchartrain, Lake Borgne, and the swamps to the east and west. Neighborhoods that sat below sea level, many of which housed the city’s poorest and most vulnerable populations, were at the greatest risk.²⁷⁵

The government, however, was slow to respond. Although Louisiana Governor Kathleen Blanco declared a major emergency prior to landfall, both the governor and Mayor Nagin had to be contacted by the National Hurricane Center on August 26 urging

²⁷⁵ “Hurricane Katrina: Facts & Summary,” History, accessed December 28, 2014, <http://www.history.com/topics/hurricane-katrina>

them to issue mandatory evacuation orders. At the time, they merely said they would “take it under consideration.”²⁷⁶ Mayor Nagin decided to issue a voluntary evacuation order on August 27, and the Superdome was opened as the “shelter of last resort” for those who could not leave the city. Finally, the National Hurricane Center Director, Max Mayfield, and President George Bush called Mayor Nagin to urge him to declare a mandatory evacuation. At the time, Mayor Nagin was consulting with legal counsel over whether he could issue a mandatory evacuation order due to liability over closing hotels and other businesses.

On Sunday, August 28, Max Mayfield briefed FEMA Director Michael Brown and DHS Secretary Michael Chertoff, as well as local and state officials, stating that the storm would cause major damage and flooding before landfall, including levee breaches in New Orleans. Mayor Nagin continued to urge people to leave the area but did not issue a mandatory evacuation order until 10am on August 28, less than 24 hours from landfall.²⁷⁷ Contraflow operations begin on roadways throughout the city, allowing all lanes of traffic to be used to lead people out of the area. By 3pm, over 10,000 people had arrived at the Superdome, and by 8pm, that number had swelled to 26,000 people.²⁷⁸

When Hurricane Katrina made landfall along the Gulf Coast on August 29, 2005, it had a Category 4 rating on the Saffir-Simpson Hurricane Scale and covered over 400 miles.²⁷⁹ The coast was pummeled with 150 mile-per-hour winds with gusts reaching 180 miles-per-hour, destroying most buildings in its path. After five long hours, the storm subsided, leaving over 150 miles of destruction along the gulf coast. The hurricane greatly affected three states: Alabama, Mississippi, and Louisiana. Mississippi received

²⁷⁶ Ibid.

²⁷⁷ “Anatomy of a National Disaster: The Consequential Timeline of Hurricane Katrina,” *The Patriot Post*, accessed December 28, 2014, <https://patriotpost.us/pages/104>

²⁷⁸ Ibid.

²⁷⁹ “Hurricane Katrina: Facts & Summary.”

the brunt of the storm, but New Orleans suffered catastrophic damage due to the cascading events that followed the storm (see Figure 22).²⁸⁰

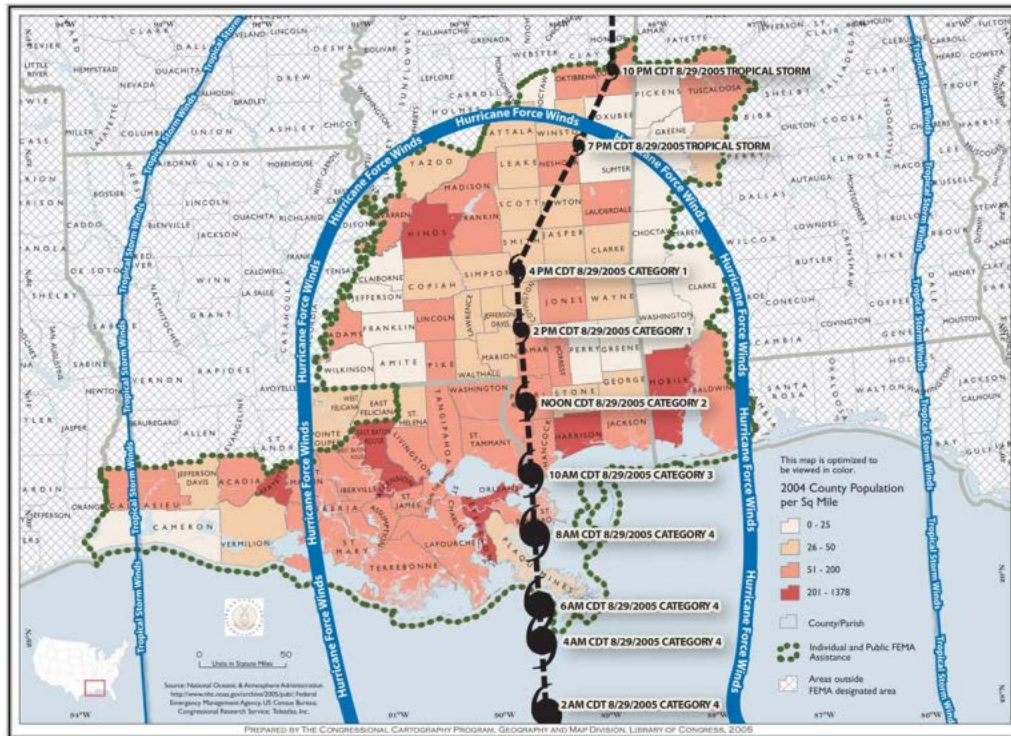


Figure 22. Hurricane Katrina: Storm Track and Counties Designated Eligible for Disaster Assistance²⁸¹

At approximately 4:30am on the morning Katrina made landfall, minor breaches in the levees surrounding New Orleans began to flood the city. After the initial breaches to the levees, other breaches soon followed, and St. Bernard Parish, the Ninth Ward, and the Plaquemines Parish began to flood. Many areas were under so much water that people had to move to attics and rooftops for safety. By 8:30am, further levee breaches caused catastrophic flooding of New Orleans (see Figure 23). By August 30, 24-hours into the

²⁸⁰ Thomas Gabe et al., *Hurricane Katrina: Social-Demographic Characteristics of Impacted Areas* (Washington, DC: Congressional Research Service, 2005), <http://www.tidec.org/sites/default/files/uploads/crsrept.pdf>

²⁸¹ Ibid.

storm, 80 percent of New Orleans was under water, and 200,000 homes were destroyed.²⁸²

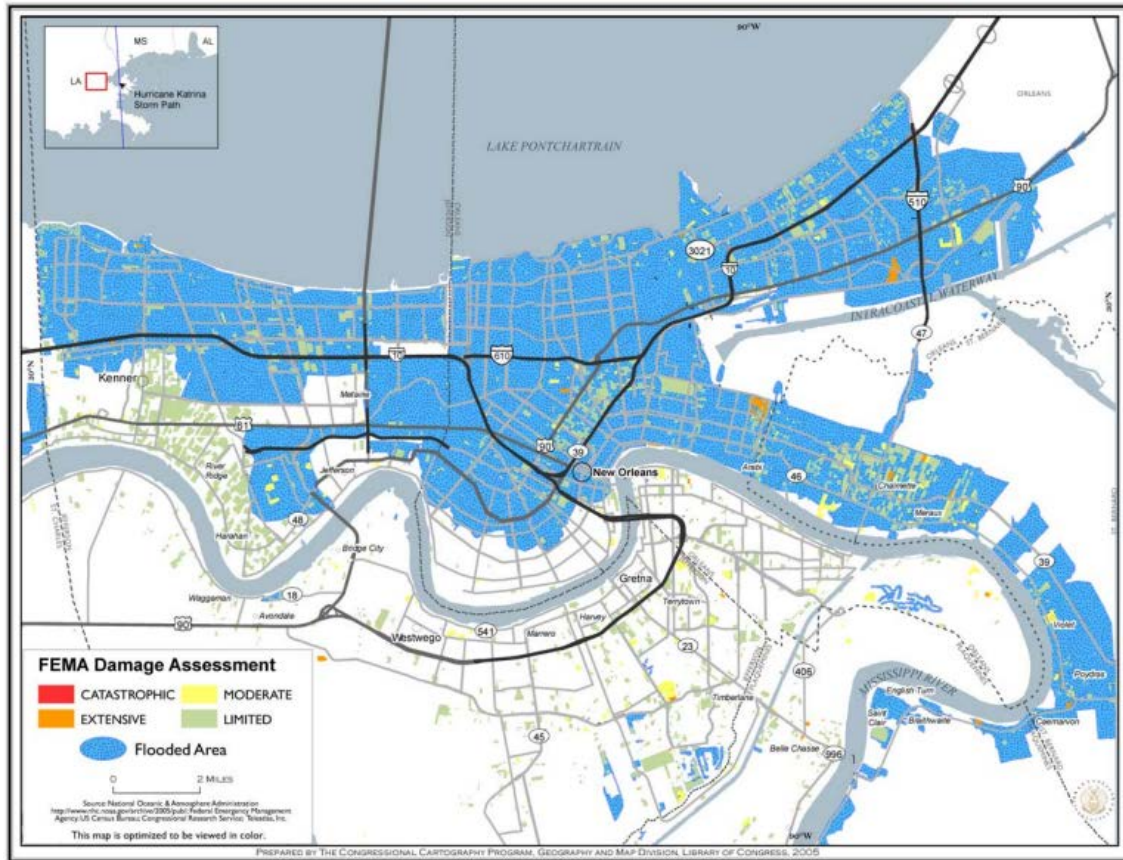


Figure 23. Hurricane Katrina Damage Assessment—New Orleans and Vicinity²⁸³

The flood waters continued to inundate the area for several days. New Orleans was left without power, drinking water, and wastewater systems. In addition, broken gas lines caused structure fires in multiple areas. The situation worsened as food supplies became scarce throughout the city as well as in the Superdome and widespread looting began. At a Wal-Mart on Tchoupitoulas Street, an initial effort to provide supplies to stranded people ended up leading to mass looting throughout the store. The Superdome,

²⁸² Margaret Crocco, ed., *Teaching the Levees: A Curriculum for Democratic Dialogue and Civic Engagement* (New York: Teachers College Press, 2008).

²⁸³ Gabe et al., *Hurricane Katrina: Social-Demographic Characteristics of Impacted Areas*.

which had been designated as one of the primary evacuation centers, was surrounded by water, making it impossible to re-supply or to complete further evacuations.

While many of the stories of this disaster are negative, there were also many organizations and individuals that provided assistance. For example, the Coast Guard rescued over 34,000 people in New Orleans alone, and many ordinary citizens saved neighbors and delivered food and supplies to those who needed it. In addition, FEMA deployed 23 Disaster Medical Assistance Teams throughout the four states most affected by the hurricane, and 10 urban search and rescue teams were deployed to assist with the rescue of stranded citizens and to look for the missing. Furthermore, U.S Department of Transportation deployed 390 trucks to deliver necessary food, water and emergency supplies. Additionally, 10,000 National Guard troops, along with 7,500 active duty troops assisted civilian law enforcement agencies to keep order.²⁸⁴

In the weeks that followed, the cascade continued with widespread looting and crime throughout the New Orleans area. Fifteen percent of the New Orleans Police force never returned to duty after the storm, leaving the city without the necessary resources to handle the increase in crime.²⁸⁵ Additionally, some police officers were charged with looting after stealing new automobiles from local dealerships and looting boarded up stores. In addition, officers were also charged with brutal beatings in the French Quarter and the shooting of a man in an evacuation zone.

Americans watched the events unfold and were shocked upon viewing the media coverage of the destruction and violence that followed the flooding of New Orleans. Instead of pulling together and supporting each other, as is seen in most disasters, America witnessed looting in the streets, heard stories of rapes and murders at the Superdome, and read about acts of violence against the responders trying to help.²⁸⁶ The

²⁸⁴ Ibid.

²⁸⁵ Crocco, ed., *Teaching the Levees*.

²⁸⁶ Douglas Brinkley, *The Great Deluge: Hurricane Katrina, New Orleans, and the Mississippi Gulf Coast*, 1st ed. (New York: Harper Perennial, 2007), 9.

combination of the hurricane, storm surge, broken levees, and the actions of the people in the area created the largest human crisis since the Civil War.²⁸⁷

In the end, 1.1 million families were displaced and an estimated \$100 billion was allocated for recovery operations.²⁸⁸ In addition, 97 percent of the population affected by flooding lived in Louisiana. St. Bernard Parish, to the south-east of New Orleans, was especially hard hit by the flooding, affecting over 95 percent of the parish population. Over three-quarters of the Orleans Parish was also affected (approximately 372,000 people).²⁸⁹ Ultimately, Hurricane Katrina claimed the lives of more than 1,300 people and led to the largest urban dislocation in U.S. history.

2. City of New Orleans—Connectedness

Connectedness involves the way in which the community works together before, during, and after a disaster. The fragility framework suggests four key factors that can make a community more fragile: loss of a community lead, isolation of the community, low social capital, and a vertical hierarchical model for response operations. Researchers have asked whether Hurricane Katrina was a disaster because of the force of the storm or because of catastrophic human failure. Or perhaps it was both. In the study of fragility in emergency management systems and community fragility, Hurricane Katrina provides a stark example of how much a community can affect the success or failure of response and recovery from a large-scale event.

Louisiana is a very diverse state with a mix of multiple cultures, ethnicities, and histories. Within New Orleans, the complexities that emerged from governance by the French, Spanish, and American governments created a cultural mix distinctive to the area.²⁹⁰ Louisiana has a total population of 4.6 million people, and approximately

²⁸⁷ Ibid., xv.

²⁸⁸ Ashley J. Craw, "Call to Arms: Civil Disorder Following Hurricane Katrina Warrants Attack on the Posse Comitatus Act, A," *George Mason Law Review* 14 (2007): 829.

²⁸⁹ Gabe et al., *Hurricane Katrina: Social-Demographic Characteristics of Impacted Areas*.

²⁹⁰ Maida Owens, "Louisiana's Traditional Cultures: An Overview," *Folklife in Louisiana: Louisiana's Living Traditions*, accessed November 28, 2014, http://www.louisianafolklife.org/LT/Maidas_Essay/main_introduction_onepage.html

378,700 people living in the city of New Orleans. Louisiana has two primary ethnic groups that make up 95 percent of the population: 63 percent Caucasian and 32 percent African American; however, in the city of New Orleans, these numbers are reversed.²⁹¹ African Americans are the ethnic majority at 60 percent of the population and Caucasians at 30 percent.²⁹²

These demographics partially illustrate why a disproportionate number of people seeking shelter in New Orleans, and three quarters of the 2,300 people reported missing were African American.²⁹³ What is more troubling, however, is why so many chose not to evacuate. Studies found, “a combination of poverty and perceptions of racism and inequities influenced African Americans to not evacuate, even after reaching the stage of high threat perception.”²⁹⁴ Additional factors include neighborhood crime and violence causing the perceived need to stay behind to protect property, and a deeply rooted culture in the area that has faced multiple hurricanes in the past. Many of these factors can be attributed to the key characteristics outlined in the fragility matrix and conceptual framework.

Community ties and a lack of social capital created barriers in evacuation as well as preparedness and planning. Due to a lack of trust, many communities did not participate in pre-disaster activities, they did not get information about the storm, nor did they heed warnings about the storm once the information was available. Additionally, while there are strong community ties within many parishes, one parish often does not communicate or collaborate with the others, leading to a form of isolation for each community. This isolation can lead to greater fragility when events such as Hurricane Katrina occur; it impedes a community’s ability obtain necessary supplies and assistance and limiting a community’s ability to recover.²⁹⁵ *The Handbook of Disaster Research*

²⁹¹ Ibid.

²⁹² Ibid.

²⁹³ Keith Elder et al., “African Americans’ Decisions Not to Evacuate New Orleans before Hurricane Katrina: A Qualitative Study,” *American Journal of Public Health* 97, no. Suppl 1 (April 2007): 124.

²⁹⁴ Ibid.

²⁹⁵ Scott Horsley Twitter, “The Ties That Bind St. Bernard Parish,” *NPR*, October 26, 2005, <http://www.npr.org/templates/story/story.php?storyId=4975511>

states, “In societies with extreme cross-cultural ethnic or racial differences, volunteering to help others outside of one’s own group at times of disasters or crisis is almost unknown.”²⁹⁶

In one study by Aldrich, three recent disasters are cited as examples of the importance of social networks in recovery. In the first, the Kobe Earthquake, killed 6,500 people and displaced another 300,000. At the one-year anniversary of this event, however, the city had restored all critical lifelines and key business operations, such as manufacturing and trade, were at 80 percent of pre-disaster levels. The 2004 Indian Ocean Tsunami, the second, caused 8,000 deaths and displaced 310,000 people. One year later the majority of schools had been rebuilt, 75 percent of the homes had been rebuilt and the majority of fisherman were back to work. In New Orleans, however, one year after Hurricane Katrina, which killed 1,600 and displaced 250,000, some neighborhoods remained untouched since the disaster. Less than half of the schools and businesses were re-opened.²⁹⁷

Upon closer examination into why New Orleans did not recover as well as Kobe Earthquake or the Indian Ocean Tsunami, researchers found that the Kobe disaster and Indian Ocean Tsunami both had more trust relationships, civic engagement, and stronger networks overall. Some neighborhoods in New Orleans, such as Village de L’Est, displayed strong ties, working together to provide recovery information, clean up the neighborhoods, and provide support to one another; however, other neighborhoods have showed very little cooperative effort. Daniel Aldrich, at Purdue University, states, “Citizens bound by fewer ties to their neighbors are more likely to engage in illegal and disruptive acts which impede recovery efforts, neutralizing positive efforts at rehabilitation efforts.”²⁹⁸

Further evidence suggests that disaster perception differs based on ethnicity, socioeconomic status, and educational levels. For example, studies have shown that

²⁹⁶ Anderson, Kennedy, and Ressler, *From Research to Praxis*,” 31.

²⁹⁷ Aldrich, “Fixing Recovery: Social Capital in Post-Crisis Resilience,” 3.

²⁹⁸ *Ibid.*, 8.

people with higher education and income are more likely to participate in disaster preparedness efforts, while those are isolated by language or ethnic barriers are less likely to participate and often do not know where to go for assistance if needed.²⁹⁹ According to the *Handbook of Disaster Research*,

While Hurricane Katrina momentarily and unavoidably called attention to issues of race and class vulnerabilities, hazards and disaster research has clearly shown that social inequalities are core conditions that shape both disasters and environmental inequalities on a global scale.”³⁰⁰

In New Orleans, the poverty rate is over 30 percent, and one in three people do not own personal transportation. This left many communities affected by Hurricane Katrina without the necessary support to prepare for the storm or to evacuate when necessary.

Another key factor in the analysis of fragility for Hurricane Katrina involves the emergency management structure and the determination of how the city of New Orleans handles disaster response. As illustrated in both the Joplin tornado and the San Diego firestorms, often the most robust systems involve a level of command and control along with a collaborative network of partners. The State of Louisiana and the City of New Orleans had a much different structure at the time of Hurricane Katrina. The ICS model was unknown to the area in 2005, and in fact, Louisiana did not use any standardized incident management model at that time. Instead, the State of Louisiana had an inflexible plan that did not allow it to effectively make decisions regarding evacuations, order necessary resources, or to even collaborate with the multitude of non-governmental partners available in the area.

Since Hurricane Katrina, a national debate has begun regarding the centralization of emergency management efforts. The failures in response after Hurricane Katrina have led to more pressure to return to a command and control approach in emergency management and more federal authority over disasters. Carole Jurkiewicz and Sean O’Keefe with the Public Administration Institute at Louisiana State University wrote an article in *Public Integrity Magazine* asserting that the “political culture of Louisiana is so

²⁹⁹ Anderson, Kennedy, and Ressler, *From Research to Praxis*,” 98.

³⁰⁰ *Ibid.*, 113.

problematic that strong federal intervention is called for if a repeat of the Katrina disaster is to be avoided.”³⁰¹ As has been shown in multiple studies and disaster samples, however, this idea is inconsistent with the shared responsibility and authority that exists in the United States between levels of government, nongovernmental partners, and the private sector.³⁰²

Studies of the effectiveness of the Coast Guard and Florida during Hurricane Katrina continue to point to collaborative accountability in disasters, leading to a “mixed form” governance network that combines a command and control system with a collaborative network.³⁰³ According to the *Handbook of Disaster Research*, “The overarching goal should be to reduce fragmentation and integrate activities both vertically among levels of government and horizontally across departments. This is especially crucial as disasters span geographic space and distinct authority domains.”³⁰⁴

3. City of New Orleans—Stability

The stability of the community involves interjurisdictional relationships, emergency management system structure, leadership, and planning models. Two primary failure points for the Hurricane Katrina disaster with regard to stability involved poor leadership at all levels of government and a lack of collaboration with outside partners, both of which are indicators identified in the conceptual framework for an increase in community fragility. From the very beginning of this incident, people perceived that leadership was lacking. The Mayor of New Orleans, Ray Nagin, blamed the state government, the state government blamed federal agencies, and the people were caught in the middle. According to Scott Shane, *New York Times* correspondent, “Some federal officials said uncertainty over who was in charge had contributed to delays in providing aid and imposing order, and officials in Louisiana complained that federal disaster

³⁰¹ Christopher J. Koliba, Russell M. Mills, and Asim Zia, “Accountability in Governance Networks: An Assessment of Public, Private, and Nonprofit Emergency Management Practices Following Hurricane Katrina,” *Public Administration Review* 71, no. 2 (2011): 218.

³⁰² Waugh, and Streib, “Collaboration and Leadership for Effective Emergency Management,” 131.

³⁰³ Koliba, Mills, and Zia, “Accountability in Governance Networks,” 217.

³⁰⁴ Anderson, Kennedy, and Ressler, *From Research to Praxis*, 178.

officials blocked some aid efforts.³⁰⁵ Meanwhile, Mayor Nagin remained at the Hyatt Hotel, overlooking the Superdome, while the city unraveled around him. Douglas Brinkley stated, in his book *The Great Deluge*, “He refused to give a pep talk, blaming the city’s communications breakdown for his decision. His primary post-storm initiative was to get a generator hooked up to the elevator so he wouldn’t have to walk all those stairs.”³⁰⁶ Would things have turned out differently if he walked over to the Superdome to offer strength and to show support for the people of his parish? Many other instances, such as riots during the civil rights movement, have shown that taking action may have made a difference. For example, Robert Kennedy walked into an angry mob after Martin Luther King’s assassination, and he offered the people encouragement and uplifting words, ultimately calming the crowd. Instead, according to Brinkley, “The Mayor was being extremely shortsighted, exhibiting childlike leadership in an adult hour.”³⁰⁷

A major turning point in the disaster occurred when the Louisiana State Governor, Kathleen Blanco, appeared on television close to tears. Instead of offering words of comfort or strength, she stated, “The devastation is greater than our worst fears. It is totally overwhelming.”³⁰⁸ There is no argument that this catastrophe was devastating and completely overwhelming. There is also no question that for the governor of Louisiana, or any other state, this would be the ultimate test of leadership; however, the power of public opinion is immense. It only takes one small sign to indicate loss of control or expertise to create a downward spiral in public opinion. Barbara Kellerman states, “When leaders lose self-control and their followers find out about it, it’s a distraction, sometimes even a major distraction.”³⁰⁹

³⁰⁵ Brinkley, *The Great Deluge*, 36.

³⁰⁶ *Ibid.*, 217.

³⁰⁷ *Ibid.*, 34.

³⁰⁸ “New Orleans: The Lost City. Teary Gov Orders Full-Scale Evacuation: Floods Threaten to KO Water Supply. Looting Chaos Spurs Martial Law,” *NY Daily News*, August 31, 2005, <http://www.nydailynews.com/archives/news/new-orleans-lost-city-teary-gov-orders-full-scale-evacuation-floods-threaten-ko-water-supply-looting-chaos-spurs-martial-law-article-1.571309>

³⁰⁹ Barbara Kellerman, *Bad Leadership: What It Is, How It Happens, Why It Matters* (Boston: Harvard Business Review Press, 2004), 96.

Governor Blanco's and Mayor Ray Nagin's actions during the course of this disaster greatly influenced the people involved. At a time when the people of their jurisdictions needed them the most, they were unable to effectively manage the job. A repeated theme from the New Orleans disaster was a lack of credibility in elected officials due to conflicting reports from local and state officials regarding the storm intensity and the importance of evacuation.³¹⁰ This caused a loss of hope and faith that the government would assist when the hurricane made landfall, ultimately leading to chaos in the weeks following the flood.

The federal government, specifically FEMA, also illustrated several major failures with regard to emergency response during the Hurricane Katrina disaster. It is quite possible that the change in FEMA from an independent agency that answered directly to the president to the Department of Homeland Security (DHS), where FEMA was merely a subset of a larger organization, may have been a major factor in the failures indicated. Many believed that due to the over-centralization within DHS, there were long delays in mobilizing and deploying critical resources during Hurricane Katrina.

Disaster relief organizations that used to deploy immediately ended up waiting for a decision to be made regarding their deployment to the disaster.³¹¹ For example, the American Red Cross was ready to respond to the Superdome to provide shelter and mass care assistance but was prevented from doing so by the Louisiana state government because its presence "would keep people from evacuation and encourage others to come into the city."³¹²

The Hurricane Katrina disaster and flooding that followed in New Orleans reveals that most governance networks within the city suffered from failures in accountability, planning, and leadership. The general lack of coordination amongst partners and agencies and the failure of initiative of the key officials caused a large-scale natural disaster to become a humanitarian crisis as well. Russell Mills, at Kent State University, states,

³¹⁰ Elder et al., "African Americans' Decisions Not to Evacuate New Orleans," 125.

³¹¹ Brinkley, *The Great Deluge*.

³¹² "Anatomy of a National Disaster: The Consequential Timeline of Hurricane Katrina."

“That a disaster of this magnitude had been anticipated, yet local, state, and national elected officials failed to collectively address the visibly crumbling levee system, points to failures in the very checks and balances to be found in a democratic accountability frame.”³¹³

The response to Katrina was not all bad. There are few examples where collaborative networks of partners created positive results in New Orleans. One primary example involves the collaborative group that created and implemented the contraflow plan, allowing unidirectional flow out of the city once evacuation orders were given. Over one million people successfully evacuated out of the affected area. Additionally, in the months prior to the disaster, a citizen awareness and evacuation guide was distributed through several partners, including the Red Cross, Wal-Mart, Home Depot, Lowes, and the major media outlets. At the state level, Louisiana used the Emergency Management Assistance Compact, mobilizing more than 220 different governmental, nonprofit, and private sector partners from around the United States. At least 535 organizations were ultimately involved in some aspect of response and recovery from this event, not including the thousands of rescuers and volunteers that also came to the area to provide assistance.³¹⁴

4. City of New Orleans—Sustainability

Unlike the Joplin tornado or San Diego firestorms, Hurricane Katrina can provide examples of all four of the key components of a lack of sustainability causing an increase in community fragility: lack of resource management and supply chain management, inaccessibility of lifelines, lack of resiliency, and the inability to recognize small system failures leading to a cascading event. The distribution of resources to people in need is not only a problem of supply and demand but also a problem of coordination. Many organizations may have had surplus supplies and resources, as was seen in Hurricane Katrina, but they may not have the means of distribution necessary to get the resources to

³¹³ Koliba, Mills, and Zia, “Accountability in Governance Networks,” 215.

³¹⁴ Ibid., 215.

people who need assistance.³¹⁵ Additionally, more vulnerable populations may not know how to get the assistance they need.

In the case of Hurricane Katrina, supply chain routes were completely cut off to organizations that had supplies but could not deliver them. The size of this disaster alone provided problems for logistics, shared resources, and demand exceeding supply capacity.³¹⁶ Many people who did not evacuate in time went to the Superdome, which was not staffed or equipped to support such a large populations, creating another logistical challenge. Further delays in resource distribution occurred due to the authority structures within the state. Very few people had the authority to authorize expenditures and resource acquisition, causing a backlog at the state EOC of requests for assistance. Additionally, as stated previously, collaborative networks and partnerships were not in place to allow for the quick and easy acquisition of supplies. Not surprisingly, Wal-Mart and Home Depot were highly successful in providing logistical support in areas affected by Hurricane Katrina because supply chain management is part of their daily business. Their plans and procedures allowed for the flexibility necessary to adapt to the incident and provide necessary support.³¹⁷

Most major lifelines were also severely impaired or completely destroyed in the city of New Orleans and in other areas throughout the state of Louisiana. But more importantly, the area was unable to quickly restore these lifelines for the affected population. Lifelines and resource management are highly interdependent systems—without one the other cannot succeed. The inability to move resources into the area kept workers from being able to restore key services, and the lack of lifelines impeded the ability to move into the area.

In most disasters, when considering lifelines, the normal response is to look at power, water, gas, and transportation infrastructure. In the case of New Orleans, however,

³¹⁵ Louise K. Comfort, Kilkon Ko, and Adam Zagorecki, "Coordination in Rapidly Evolving Disaster Response Systems: The Role of Information," *American Behavioral Scientist* 48 (2004): 302.

³¹⁶ Ibid.

³¹⁷ Comfort, Ko, and Zagorecki, "Coordination in Rapidly Evolving Disaster Response Systems," 455.

an argument could be made that the vital lifelines for restoration and recovery were also the community members themselves. Comfort, Ko and Zagorecki state that a disaster “threatens not only the destruction of technical infrastructure such as power lines, roads, and communication lines but also the social, organizational, and economic structures that support the daily operations of the community.”³¹⁸ Without such lifelines, the chance of restoration diminishes considerably.

This interconnection between technology and social systems creates a system that can be very fragile to shocks and disturbances. If these small disturbances are not recognized as they occur, cascading events may follow causing a complete system failure. The *Handbook of Disaster Research* calls the factors leading to collapse of a system as pathogens. It notes they are present long before the disaster, and in the process of leading up to the disaster, they combine and create disruption, threatening the overall system.³¹⁹ Hurricane Katrina, unfortunately, provides an example of these cascading failures and how the state and the nation were ultimately affected.

The most obvious example is the breach of the levees surrounding the city of New Orleans. Many have noted that weaknesses in these levees were known prior to Hurricane Katrina and that many of the levees were not built to withstand a storm surge created from a Category 4 or 5 hurricane.³²⁰ Second were the warnings from the National Hurricane Center stating that this storm would cause disruptions to the levee systems, causing a potential collapse, and flooding into populated areas. With this information, evacuation orders were still delayed, leaving people too little time to get out of the area before flooding occurred. Once the levee system started to show signs of stress, it was too late to try to avoid the smaller system failures, and the disaster reached a tipping point leading to a catastrophic failure with multiple cascading events to follow. Being able to recognize any of these failures would have allowed community leaders and elected

³¹⁸ Ibid., 297.

³¹⁹ Anderson, Kennedy, and Ressler, “From Research to Praxis,” 46.

³²⁰ Michael Grunwald, and Susan B. Glasser, “Experts Say Faulty Levees Caused Much of Flooding,” *The Washington Post*, September 21, 2005, sec. Nation, <http://www.washingtonpost.com/wp-dyn/content/article/2005/09/20/AR2005092001894.html>

officials to assess the future demand for resources and services and proactively prepare for the worst case scenario.

However, the most striking out of all the factors studied is the lack of resiliency in the New Orleans area following Hurricane Katrina. Some have commented that they could not have possibly predicted a disaster of this magnitude, but this was not the first time that the city had been destroyed by hurricanes. In the last century alone, New Orleans has been flooded six times: in 1915, 1940, 1947, 1965, 1969, and 2005.³²¹ In an area so prone to disasters, specifically hurricanes and flooding, it is surprising that city officials did not have more measures in place to protect people and property, and that they did not foresee a disaster of this magnitude as a possibility. A common theme after disasters is to return to normal or to rebuild; however, in an area that has repeatedly been destroyed by flooding, does it make sense to rebuild and put people back into harm's way?

The definition of resiliency is to "bounce back" from a disaster. Although this has happened in the Kobe Earthquake and Indian Ocean Tsunami examples, New Orleans has struggled in this endeavor more than other areas affected by catastrophic disasters. A total of 236,970 people left Louisiana between July 2005 and June 2006, largely due to Hurricane Katrina, and only 100,000 of those people have returned.³²² The lack of employment is cited as the single greatest reason for this downturn.³²³ Furthermore, businesses have not returned, and some neighborhoods continue to work through the daily complexities of rebuilding efforts 10 years later. By all accounts, New Orleans has illustrated a lack of resiliency after Hurricane Katrina.

5. Summary Analysis of Hurricane Katrina in New Orleans

The scope and nature of Hurricane Katrina was unique in the United States. Though hurricanes have made landfall in the past, and catastrophic damages have

³²¹ "Hurricane Katrina- Facts & Summary."

³²² Ibid.

³²³ "New Orleans' Katrina Recovery Slows as Most of Louisiana Loses Population to Rest of Country," *The Lens*, February 4, 2014, <http://thelensnola.org/2014/02/04/new-orleans-katrina-recovery-slows-as-most-of-louisiana-loses-population-to-rest-of-country/>

occurred, the human side of disaster has never been shown in such stark light as with this disaster. Katrina provides an example of how the loss of either a technological or a social system can have meaningful impacts, and how both are interconnected to the point where they cannot be treated separately. As illustrated in the framework analysis of this disaster (see Figure 24), New Orleans lacked many of the key factors required to decrease community fragility from disasters, from connectedness to stability and sustainability.

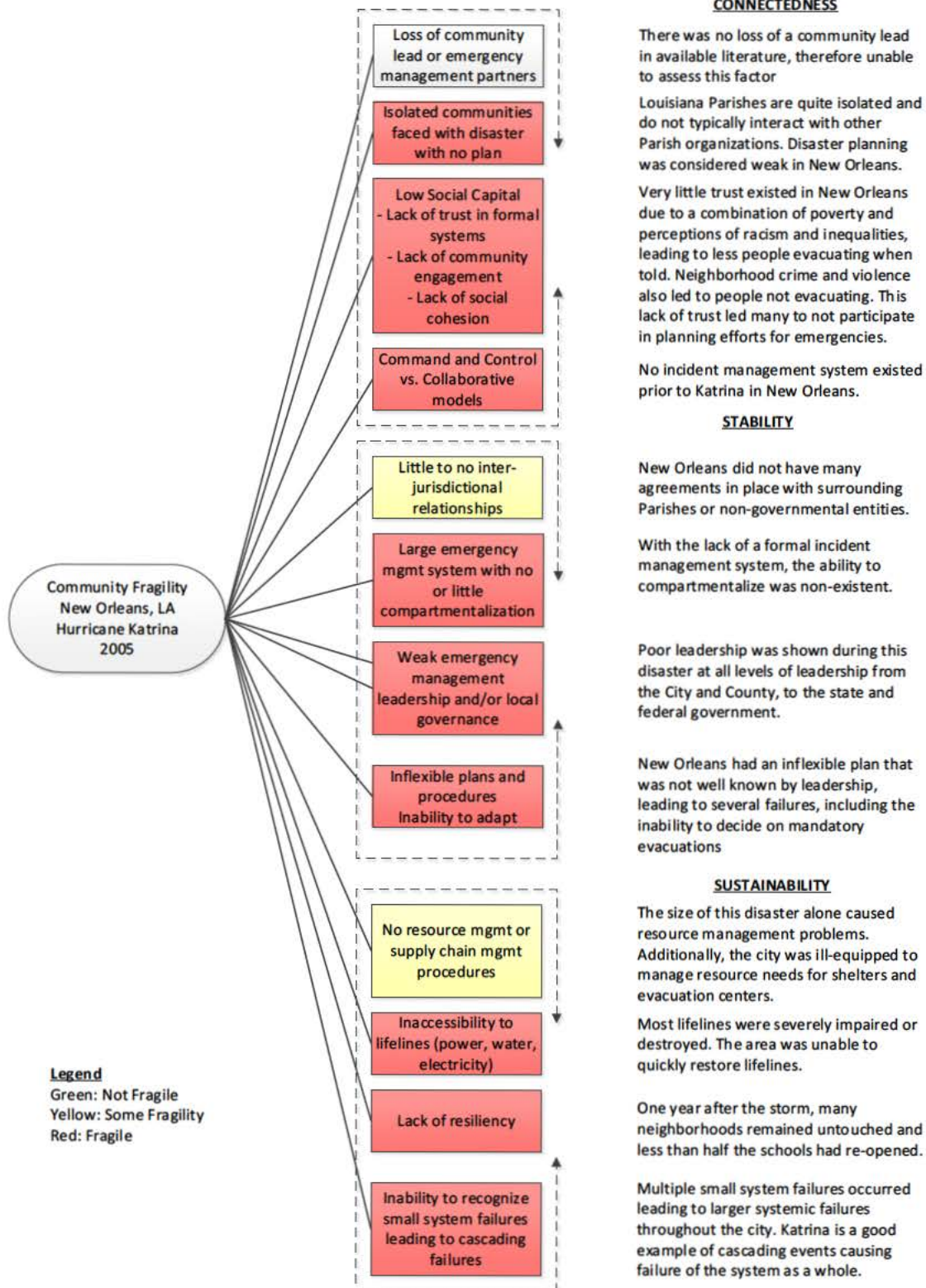


Figure 24. Fragility Framework—Analysis of New Orleans, LA, 2005 Hurricane Katrina

Each component of the theoretical framework on community fragility is easily illustrated through this disaster, from the lack of leadership causing social chaos to cascading system failures leading to catastrophic failures in New Orleans. This year marks the 10-year anniversary of Hurricane Katrina, and it is hoped that the wealth of information collected about this disaster can be used as lessons learned for other jurisdictions to avoid the pitfalls and challenges presented.

E. CASE STUDY ANALYSIS CONCLUSION

Through a review of literature on systems fragility, a number of key factors were constructed and placed into a fragility matrix to illustrate overarching and repeating themes. This matrix led to the development of a theoretical framework on fragility in community and emergency management systems, showing a cross-reference between general systems fragility and those factors that could be used to most specifically measure fragility before, during, and after disaster. From there, the framework was assessed using three specific case studies: 2011 Joplin tornado, 2007 San Diego firestorms, and 2005 Hurricane Katrina.

Interestingly, the three event samples turned out to illustrate three distinct patterns of assessment for community fragility. Each was catastrophic in nature, affecting not only the local communities but the state as a whole, and each occurred in the last decade where national standards have been present for emergency management. The Joplin tornado illustrated how each of the components in the framework could be used to decrease fragility overall. By all accounts, this disaster was considered successful and many of the assessment measures were used by the city of Joplin prior to the tornado, possibly decreasing their fragility. The San Diego firestorms also provided several areas where preparedness practices and mitigation could improve the community's resiliency to disasters, but it also provided clear examples of how weaknesses in social capital and resource management could have devastating effects. Finally, the Hurricane Katrina case study provided the other side of the spectrum, illustrating several weaknesses and failures that led to catastrophic collapse of systems within the city of New Orleans. This case study provides more information about the importance of social capital than the others,

and it provides lessons in how isolation of communities, lack of leadership, and fractured supply chain management mechanisms can drastically affect a community after disaster. It also suggests that flexibility in planning, adaptability to disturbances, and interjurisdictional relationships can decrease fragility before a disaster occurs, making them better able to handle the disaster when it comes.

V. CAUSAL PREDICTION MODELING

“The ultimate authority must always rest with the individual’s own reason and critical analysis.”

–Dalai Lama

A. INTRODUCTION

The multi-method approach to this research has led to several areas of analysis and findings that ultimately answer the key questions this thesis seeks to answer. This chapter will expand upon the analysis provided by the literature review, conceptual development, and each of the three individual case studies to provide a combined analysis of fragility in emergency management (see Figure 25). An examination of the initial conceptual framework follows, leading to the development of a causal prediction model for the future.

Although fragility has not been extensively studied in the emergency management field, the study of systems has proven to be helpful in determining how to best measure fragility in this context. Many of the key themes of fragility that emerged from the literature on complex systems intuitively seem to also belong in the emergency management arena. For example, without connections between systems, how could emergency managers obtain the information and resources necessary to effectively respond to an event? How would they even know what was needed? Thinking something is intuitively connected and actually being able to illustrate it are two different things. Therefore, the case study analysis provided the necessary avenue to determine if the constructed framework is actually a valid tool for determining if the literature on systems fit into another field all together.

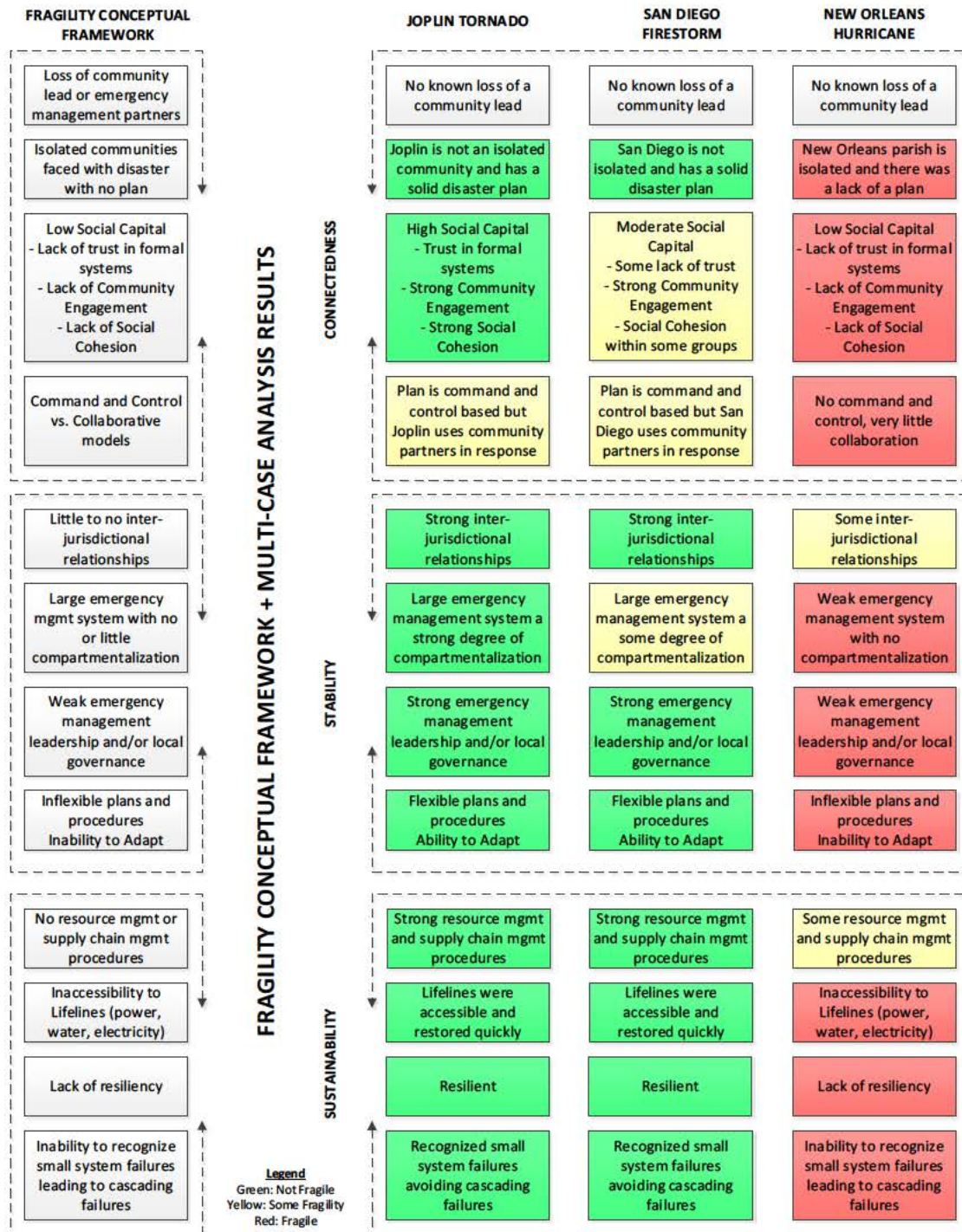


Figure 25. Fragility Conceptual Framework with the results of the Multiple-Case Analysis

B. ANALYSIS

Each of the case studies were catastrophic events for the communities affected, and all three placed a large strain on the emergency management system from local to state and federal resources. On a spectrum, however, the Joplin case study would be at one end, described in the literature as a successful response and fast recovery, and New Orleans would be at the other end, with the majority of the literature describing the number of lessons to be learned from a failed response and slow recovery. San Diego falls in the middle of the spectrum with many favorable reports and systems in place and other areas of reported weakness. Each of these was analyzed separately in Chapter IV. The following sections provide a closer look at the fragility factors under connectedness, stability, and sustainability to determine how valid each measure is to determine fragility in emergency management.

1. Connectedness

The four areas of connectedness evaluated for each case study include: the loss of a community lead, the isolation of a community, social capital, and the structure of the emergency management system (see Figure 26).

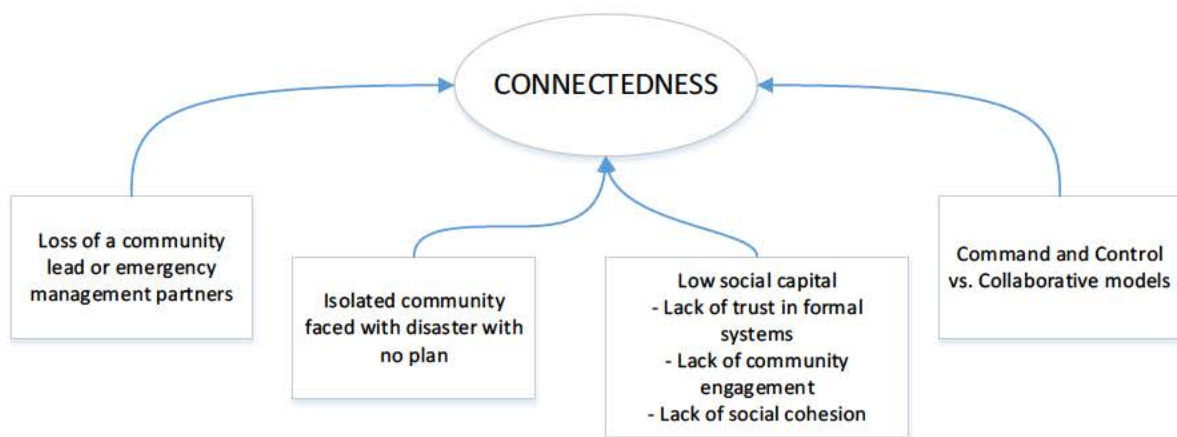


Figure 26. Fragility Factors for Community Connectedness

None of the case studies provided the ability to measure whether the loss of a community lead or emergency management partner would have created greater overall fragility. Due to the strength of this claim in the literature, however, it was not removed from the theoretical framework and is retained in the predictive model despite the need for additional research to more fully support its inclusion.

Both San Diego and Joplin are well-connected communities with multiple networks connecting their systems to others. Each is also along major transportation routes leading to the ability to seek assistance from a variety of sources. The New Orleans Parish was the only case study that illustrated the effects of an isolated community. As mentioned previously, many of the parishes within southern Louisiana are highly individualized and unlikely to interact across borders. This type of isolation, combined with little disaster planning, ultimately played a role in the breakdown of assistance available. This measure was easy to identify in each community and, therefore, remains as part of the framework. Because transportation hubs were so important in all of these case studies, transportation was added to this factor specifically.

Unsurprisingly from the amount of research available, social capital became a prime indicator of fragility within each of these case studies. Areas with high social capital had a greater ability to adapt to changing circumstances. In areas where there were perceived inequalities, such as the migrant workers in San Diego or the racial disparity in New Orleans, there were barriers to response. Trust also came out as one of the key components of measuring social capital in each of these cases, specifically the trust in elected and key government officials.

The final factor in the framework for connectedness is the structure of the emergency management system. Initially, the research indicated that a command and control model would lead to difficulties due to the fact that non-governmental partners do not report to government entities. A horizontal collaborative model is suggested in several papers as an alternate to ensure inclusion of multiple partners; however, the case studies showed that from a fragility perspective, a hybrid approach is actually best. There has to be some form of vertical hierarchy when establishing authority structures and when working with state and federal officials for support; however, a collaborative

approach leads to more partners with the ability to work together. Much like the model adopted in San Diego, an incident management system that allows for the flexibility and adaptability to bring in non-governmental partners is required. Therefore, this factor was slightly changed to allow for the hybrid approach to decrease fragility.

2. Stability

The second area of focus in determining fragility of a community involves areas that either increase or decrease stability. The four factors outlined in the framework were: interjurisdictional relationships, compartmentalization of the emergency management system, leadership, and the flexibility in emergency plans (see Figure 27).

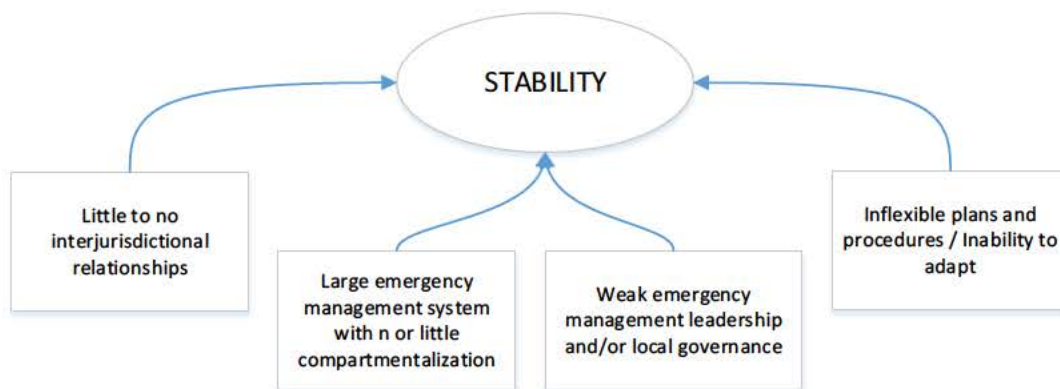


Figure 27. Fragility Factors for Community Stability

Each of these four factors is apparent in all three of the case studies. The strength of interjurisdictional relationships is closely tied to the degree of connectedness as described above. Connectedness deals with the structure of the emergency management system; however, where this factor is more about the strength of the relationships themselves. Do they exist? If there is a need, are there organizations that can fill the need for the jurisdiction? Joplin, Missouri provided the best example of the utilization of multiple non-governmental partners, specifically the faith-based community, to assist in both day-to-day operations as well as emergency response and recovery. On the other hand, the relationship San Diego had with the Border Patrol actually worked against it in the sheltering of community members since a trust relationship had not been established.

Therefore, where strong relationships are necessary, those relationships should also be weighed against the need to ensure it is the right fit. In New Orleans, many of the non-governmental partners were not allowed to respond, which caused great tension between governmental jurisdictions and support entities.

Compartmentalization of the emergency management system is more difficult to assess. The San Diego example provides the best opportunity to see how this measure would work since it had multiple command organizations and coordination centers focused on specific areas of response, such as evacuation, sheltering, emergency notifications, firefighting, public information, etc. In this case, however, they also had communications difficulties between each group. Therefore, in order for this factor to work effectively, strong communications networks must be established between each group to ensure appropriate situational awareness and improved response.

One of the strongest factors to promote stability of a community is leadership. Where leadership falls short, such as it did in the New Orleans example, trust diminished and chaos ensued. In the areas where leaders were visible and communicated strength in the face of adversity, community members and groups rallied around them to help support the response and recovery operations.

The final factor to determine stability of a community is the presence of emergency plans and procedures that are flexible and adaptable. The Joplin case study illustrated that the community had a very structured plan but were able to move beyond that structure when necessary to ensure successful disaster response. In New Orleans, there was very little knowledge about the plan, which was illustrated when Mayor Nagin delayed the mandatory evacuation of the city to consult with legal counsel over the legality of such measures. Additionally, neither Mayor Nagin nor Governor Blanco showed understanding of emergency planning and the responsibility of local government in disaster response. In contrast, both San Diego and Joplin showed a unified effort between local and state officials, providing a clear line of authority and responsibility in utilizing state and federal systems. This factor was very influential in determining a community's ability to recover.

3. Sustainability

The final area of focus involves factors that increase or decrease the sustainability of a community after a disaster. As stated previously, resilience is the current favorite term for many organizations to describe the strength of a community post-disaster; however, resilience is only one of four factors that determine sustainability. The other three consist of: resource management and supply chain management procedures, the ability to restore lost lifelines, and the recognition of small system failures that may lead to a cascade of failures (see Figure 28).

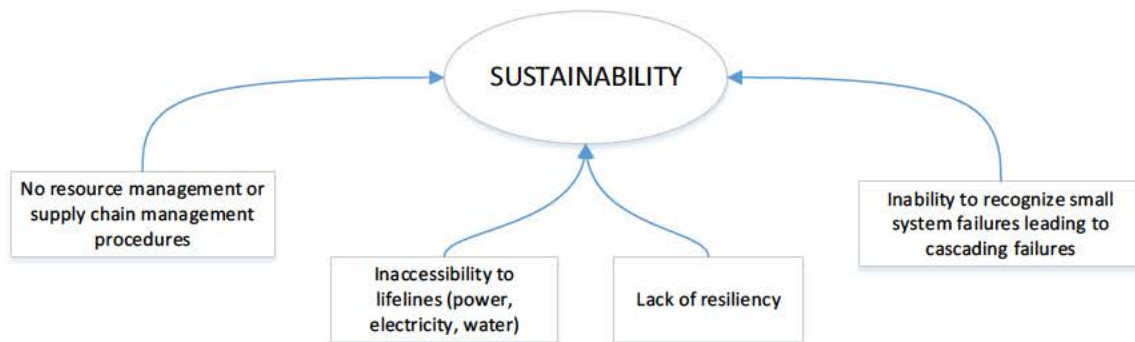


Figure 28. Fragility Factors for Community Sustainability

The ability to access critical resources in times of need is essential for a community's recovery. The question that needs to be answered, however, was whether the lack of resource and supply chain management could lead to increased fragility of a community. In the Joplin case study, very few articles mentioned anything about a need for resources. Due to Joplin's central location between four states, its ability to receive resources was not hampered and its plans seemed to be strong. San Diego also had strong plans for resource management through the Incident Management System. Due to the size of this disaster, and the fire jumping the major freeway, it did report the inability to get the right resources at the right time. This lack did not affect the community's ability to recover as the delays in getting resources were small. In New Orleans, however, resource management was a critical factor in the community's ability to recover. The Superdome is the most visible example of thousands of people without the necessary food and water to support them as the water surrounded them and cut them off from the

rest of the community. The lack of a plan in this respect led to many of the difficulties and also decreased the trust in local officials. Additionally, due to the scope of this disaster, across multiple states, resources often had difficulty getting into the area. Supply chain management did not seem to be a consideration in planning efforts. Other communities in similar circumstances have flown in supplies as necessary until roads and bridges were repaired to ensure the community was able to manage during short-term recovery; however, this did not happen effectively in New Orleans. This example illustrates how the inability to receive and distribute supplies and resources can lead to an increase in fragility of a community.

Along these same lines, the ability to restore lifelines is evaluated as a measure of fragility. Much like resource management, if lifelines cannot be restored quickly, the community will suffer longer and the possibility of secondary consequences increases. The Joplin case study demonstrated this understanding. The city developed priorities and timelines to re-establish lifelines, such as the opening of roads and medical facilities, and it met each one. This further established trust with the community members and allowed support organizations to continue working in the disaster area. On the other hand, the New Orleans example is an extreme case of the loss of lifelines. Also, due to Hurricane Rita following on the heels of Katrina, some lifelines were further delayed. That being said, redundant systems and lifeline support were not mentioned in planning documents or as priorities for the city. This disaster is more difficult to evaluate, however, due to the magnitude and the area affected.

Resiliency was originally evaluated based upon the community's ability to "bounce back" or recover after disaster. Joplin, Missouri provided the best example of a community that was able to bounce back after the tornado. Within a week businesses were re-opening and the community organizations helped to ensure schools could open and community services continued. On the contrary, the New Orleans case showed that resilience was lacking. One year after the hurricane, many people had not still returned to New Orleans, and hundreds of businesses never re-opened their doors. Entire communities changed overnight as well as new groups moved in and changed the structure of the community for the future.

The San Diego case study illustrated a lack in the fragility framework for emergency management. San Diego uses strong mitigation measures, specifically for the wildfire hazard. Years of efforts between building officials, land use planning officials, and wildfire officials led to a decrease in overall risk to property for many community members. Defensible space measures illustrated how a community could decrease risk from specific hazards in its area. This same concept could be used in tornado areas, such as Joplin, and in hurricane zones, such as New Orleans. Both have repeated danger from these types of storms and both could utilize building and land use codes to decrease the risk and improve the ability of the community to recover after the next disaster. Therefore, mitigation measures have been added to the model for future consideration.

Finally, community sustainability was evaluated based upon the ability to recognize small system failures before they became larger or systemic failures. Both the Joplin and San Diego cases provided information about small weaknesses or failures that were addressed quickly. For example, when resource shortfalls were noticed, both communities quickly adjusted and were able to get resources from other sources quickly. In contrast, the New Orleans case illustrated the absolute necessity to recognize small failures before they lead to system collapse. Multiple small system failures occurred during the days leading up to the storm without recognition or action. For example, the city of New Orleans had over three days' notice of the oncoming storm; the weather prediction center urged people to evacuate and predicted several levee failures. When one levee failed, it was inevitable that more would follow. Therefore, instead of merely facing a hurricane, the city had to face wide-scale flooding throughout most of its area. The lack of trust in key officials, such as law enforcement and elected officials, and also led to many refusing to evacuate, which in turn led to the human crisis that followed. Each of these single points of failure could have been avoided or remedied before full system failure occurred.

C. CAUSAL PREDICTION MODEL

From the information provided in all three case studies, the theoretical framework developed through the literature review was adjusted, allowing for the development of a causal prediction model. This model indicates those factors identified in this research that help explain and predict the fragility of communities and systems in the emergency management field. The model, Figure 29, flows from left to right answering the question: IF X factor THEN Y community characteristic THEREBY Z fragility outcome.



Figure 29. Causal Prediction Model of Community Fragility in Emergency Management

In this case, the model outlines each of the factors relevant from the case studies on the left. In the middle are the three primary categories for each factor: connectedness, stability, and sustainability. If the factors on the left are true, then it is expected that each of these categories will also be strengthened. If all three areas are strengthened, then it is also expected that the overall fragility of a community would be decreased and the community would not only be able to recover quickly but would also be stronger for the next disaster.

D. CONCLUSION

The analysis of the three primary characteristics of fragility, using a multiple case study method, provides the necessary information to determine how each may play a role in this new model of community fragility in emergency management. More than anything else, this research shows that this is a complex endeavor, involving several moving parts, all working as one to ensure successful recovery. Each disaster is unique, and each will have its own set of challenges. Through a multi-method approach, however, fragility may be reduced no matter what the circumstance.

VI. FUTURE CONSIDERATIONS, RECOMMENDATIONS AND CONCLUSION

“The past, like the future, is indefinite and exists only as a spectrum of possibilities.”

–Stephen Hawking

This thesis introduces the idea of community fragility to the study and practice of emergency management. The assertions made at the beginning of this paper were that 1) there is a gap in the current emergency management literature and policies with regard to community fragility and what causes systems to fail, and 2) there should be a way to qualitatively measure fragility as an emergency management concept. These assertions were tested through the creation of various research products. The existing literature on fragility in complex systems provided the basis for a conceptual framework on fragility in emergency management. The multiple case study analysis allowed this framework to be evaluated and ultimately led to a community fragility causal prediction model, which reveals the factors and characteristics that drive community fragility and underlie a community’s ability to recover from and thrive following a catastrophic disaster. This naturally leads to additional questions and research possibilities in the field of emergency management.

A. FUTURE RESEARCH

This research is only the first step in determining if fragility is a valid concept for emergency management. The research provides several indicators of fragility from various complex systems and provides examples of how those indicators could be used in the analysis of past disasters. The analysis also suggests a few different directions for future research on community fragility in emergency management.

First, further research is needed to determine how each area of fragility can be measured. This thesis illustrates how each could be applied to a disaster in the United States, but further analysis is needed into each indicator of fragility to determine how it is measured. For example, how does one measure the isolation of a community? Is it

through ingress and egress routes, critical infrastructure access, or through the community members themselves? If measurement of these factors is possible, then further research could determine whether the factor increases or decreases fragility and to what degree.

Second, further research has the potential to determine if the utilization of these indicators before a disaster could have positive effects after a disaster. For example, would actions within the community to increase social capital decrease civil unrest in incidents similar to the Los Angeles riots of 1992 or the community protests following officer involved shootings, such as the Ferguson Missouri shooting of Michael Brown in 2014? The case studies suggest a connection through the actions of leaders, community structure, and the trust in formal systems. Further research is required, however, to determine whether a direct connection exists between each factor to increased or decreased fragility in these incidents.

Finally, a discussion is required about the ways in which to utilize each indicator in the emergency management field for the greatest overall benefit to the community served. Once measurement has been established and the indicators of fragility have been shown to have a positive effect on outcomes, further research is needed to show how that information could lead to stronger emergency management systems and a change in policy direction to allow for a broader scope in mitigating disaster.

B. CONCLUSION

Emergency management involves various parts and pieces all working together toward a common goal, whether that goal is to better prepare a community, mitigate against future harm, respond to an event, or provide for the effective recovery of a community after disaster. Each piece is important to the success of the networked system, and a failure in one area could very well lead to a cascade of events that cause a collapse of the system as was shown in the Hurricane Katrina case. On the other hand, by fostering these networks and looking at them from a broader point of view, we may be able to identify small failures early and correct them before they lead to a cascade, much like the San Diego firestorm case where the community learned lessons as they moved

through the disaster and responded swiftly to the changing environment. The Joplin tornado case illustrated the enormous benefit of social systems working together with technical systems to provide the best support to a community.

Each one of the case studies chosen for this research illustrated key concepts that are critical to emergency management when looking into the future. The first is the understanding that our disaster landscape is not the same as it was when the discipline of crisis management emerged in the 1950s and 1960s. At that time, crisis managers looked at a specific problem or a potential disturbance within a system. The aim was the same—to stop a cascading event from occurring. However, it was assumed that the triggering event would be stable and recognizable. With the increase in complexity in the twenty-first century, along with our highly interdependent global network, we have entered into a new era where we face greater instability and less recognizable problems.³²⁴ This research illustrates this new environment by outlining various factors of fragility from a systems perspective in a diverse manner. The research does not end at risk and vulnerability assessments; instead, it recognizes the importance of these factors along with the social structure of a community, the leaders who shape policy, the interdependencies in our critical infrastructure, the structure of emergency management systems, and the people who put it all together.

Three themes have emerged from an examination of the research: connectedness, stability, and sustainability. Recent trends have shown an increase in focus upon resilient communities, but as shown in this research, resiliency is merely one factor of the whole. Along with resiliency, there are factors that affect the sustainability of a community. Additionally, the connections between community members, public officials, and emergency management practitioners play a role as well as the overall stability of the community before the disaster strikes. This could explain why plans and procedures so often fail despite the best efforts of everyone involved—they were looking through a lens that was too small.

³²⁴ Anderson, Kennedy, and Ressler, “From Research to Praxis,” 490.

The concept of fragility alone is significant to the field of homeland security and emergency management. While studied in several other disciplines and fields, the term is just beginning to gain momentum in the area of disaster management. This causes a change in focus; instead of looking merely at how to reduce a threat, the study of fragility allows emergency managers to turn around and see the connections between multiple parts and pieces of the whole. Everything may be planned out well and executed as expected, only to see the event unravel and fail; however, a focus on fragility brings to light areas previously hidden that explain these failures and provide a roadmap to success in the future.

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